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NATIONAL FIRE PROTECTION ASSOCIATION

Quarterly

Published Quarterly at Boston, Mass., by the
NATIONAL FIRE PROTECTION ASSOCIATION
International

...THE MORNING AFTER

In the middle of the night fire hit this plant with sudden, blasting fury. Started in oil storage and spread like lightning. Next morning the directors could rightfully ask, "*Where was our fire protection?*"

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Volume 46 July 1952 Number 1

Quarterly

The Standard Technical Journal of Fire Protection for More Than Forty Years

of the

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International

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The National Fire Protection Association is a non-profit technical and educational organization devoted to the reduction of loss of life and property by fire with more than 14,000 members. The *Quarterly* is one of the publications regularly provided to members. Other membership publications include a monthly *Fire News, Advance Reports* and *Proceedings* of the Annual Meetings, a *Year Book,* and many leaflets, pamphlets and posters issued throughout the year on fire prevention and control.

Technical committees of the Association develop means to safeguard life and property through the publication of standards covering all phases of fire prevention and protection. Your membership in the Association (annual dues $12.50) affords an opportunity to keep abreast of these developments and, by being a member, you help support this humanitarian activity. Popular educational literature on fire safety is constantly being produced by the NFPA for distribution through its members to the general public.

All members of the Association and the public are invited to NFPA meetings. The following dates are now on the Calendar:

NFPA Calendar

1952	
Oct. 5-11	Fire Prevention Week.
Dec. 1-3	Regional Meeting, Houston, Texas.
1953	
May 11-15	Annual meeting, Palmer House, Chicago.

The closing date for articles submitted for the Quarterly is the 15th of the month preceding publication.

Quarterly

of the

NATIONAL FIRE PROTECTION ASSOCIATION

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Volume 46 **July 1952** **Number 1**

Table of Contents

Kerosene Tank Fire, Corpus Christi.....Frontispiece

New Developments in Upright Sprinklers..... 5
Norman J. Thompson, Director, Factory Mutual Laboratories

LP Gas Bus Fueling Station, San Antonio..... 19
Hugh V. Keepers, Assistant Manager,
Fire Prevention and Engineering Bureau of Texas

Million Dollar Pier Fire, Vancouver, B. C..... 27

Automatic Fire Detection for the Home..... 32
W. G. Holmes, Secretary, Automatic Fire Alarm Association

Meetings of Board of Directors
New York, June 9, 1952..... 40
Boston, July 14, 1952..... 41

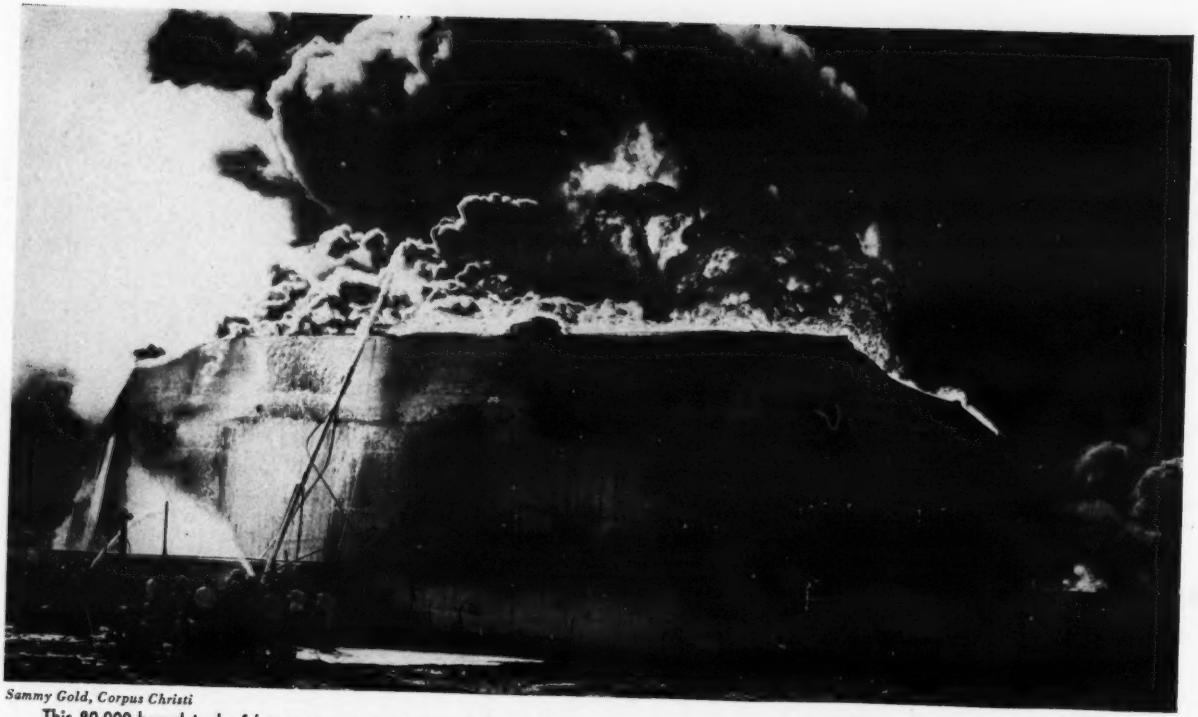
LP Gas Fires and Explosions, *An NFPA Staff Study*..... 46
Habitational Occupancies..... 47
Mercantile Occupancies..... 50
Manufacturing Occupancies..... 56
Storage Occupancies..... 61
Transportation Equipment..... 61
Garages and Service Stations..... 68
LP Gas Bottling and Distribution Plants..... 71
Miscellaneous Occupancies..... 76

Extinguishing Oil Tank Fires by Agitation..... 83
J. L. Risinger, Socony Vacuum Oil Company

Water Works Revenue for Fire Protection..... 93

Index to Advertisers..... 100

Accounts of fires appearing in the Quarterly are copies of or extracts from reports forwarded to the Association except where otherwise indicated. The Association, as a body, is not responsible for the statements or opinions of any of its members. This publication is indexed by Engineering Index, Inc.



Sammy Gold, Corpus Christi

This 80,000-barrel tank of kerosene was the starting point of a serious fire in Corpus Christi, Tex. on May 16, 1952 which heavily damaged the property of the General American Tank Storage Terminals and the Southwestern Oil and Refinery Co. Originating in the tank while it was being filled with kerosene at a temperature of 117°F., the fire is assumed to have been caused by a static spark. Flaming oil spread outside the original diked area through openings in the dike walls and over one dike into the refinery area. Fire fighting was handicapped by lack of installed foam or equivalent protection, the imperfect dikes, the sloping salt marsh ground, and congested conditions in the adjoining refinery.

New Developments in Upright Sprinklers*

By Norman J. Thompson
Director, Factory Mutual Laboratories

Since the first automatic sprinklers were installed about 75 years ago, there have been many improvements mostly resulting in improved dependability and sensitivity. As far as distribution of water is concerned, some changes were made to obtain a broader ceiling coverage; around 1930 or soon afterwards, the special pendent sprinkler was introduced. Considering the almost total lack of fire test data and the limited experience available 50 years ago, the record of automatic sprinklers has been a tribute to the judgment of those who designed sprinklers at that time.

Increased Occupancy Hazards

The conditions under which our present standard sprinkler heads have built up their good reputation have been undergoing a change over the years which imposes greater and greater burdens on fire protection. Individual building areas have increased so much that in the event of failure of sprinklers to cope with any fire hazard, the resulting loss may be much greater than formerly. In addition, hazardous materials and processes which were relatively unknown 50 years ago have been introduced into many manufacturing lines. Probably the greatest factor, however, has been the increased piling of combustible stock and manufactured products to heights which were impracticable before the general use of the modern lift truck. The quantities of goods so stored in warehouses have also increased at certain times of the year because of the desire of manufacturers to maintain a reasonably uniform production rate in spite of a widely varying seasonal demand.

High piling of combustible materials not only produces a condition contributing to greater fire severity, but when such piling extends to elevations only a few feet from ceiling level, the protection effectiveness is impaired on account of poor distribution from sprinklers at these high levels. In some instances a sufficient remedy is obtained in reinforcement of the water supply to obtain a good flowing pressure even with a considerable number of sprinkler heads in operation. Another remedy is to decrease the area protected per sprinkler head, but this requires repiping of the entire sprinkler system which is a costly operation. Furthermore, an increase in the number of sprinkler heads in any area usually requires a correspondingly stronger water supply.

Early Experimental Work

If we watch a standard upright sprinkler head in operation, it is obvious that the sprinkler head wets directly only a small proportion of the ceiling area, and the approximate 60% of the water discharged upward against the ceiling falls in the form of very large drops relatively inefficient in their capacity to cool the atmosphere. However, until we obtained our improved testing facilities in Norwood during World War II, we were unable to demonstrate by actual test that improved protection could be obtained with radically different types of distribution. At the same time we found in our war-time research

*Based on a talk presented at the 56th Annual Meeting of the NFPA, June 9-13, 1952. (Program Item No. 99.)

installed foam or equivalent protection, the imperfect dikes, the sloping salt marsh ground, and congested conditions in the adjoining refinery.

work that active flaming combustion on smooth wood ceilings would not persist if the temperature of the air adjacent to the wood surface was prevented from rising substantially above 1000° F., although glowing combustion might still persist.

Our first investigation and test program included fire tests with various types of standard approved upright sprinklers at various pressures and in both ½ and ⅜ in. sizes. The results were compared with those obtained from pendent spray nozzles which discharged no water onto the ceiling so that by 1947 we were pretty well satisfied that the protection afforded by wide angle pendent spray nozzles was much better per gallon of water used than that which would be obtained from standard automatic sprinklers. The progress of our work was speeded up by the availability of the first very wide angle, individually automatic, spray nozzle in commercial form during 1949.

Improved Upright Sprinkler

We first used standard commercial approved sprinklers with a superimposed metal disc to deflect the normal upward discharge of the sprinkler laterally. A considerable improvement in the protection immediately resulted even though the distribution was far from uniform. We also tried approved upright sprinklers in the pendent position so that instead of discharging 60% of the water upward, this proportion was discharged downwards. In this case, also, the protection was substantially improved.

Our development work on an improved upright sprinkler head was very much facilitated by the availability of two commercial sprinkler heads with frames fairly well streamlined in the vicinity of the boss, so that we could use these commercial heads with superimposed flat discs and altered deflectors to obtain much better uniformity of distribution over that obtainable with the standard head deflectors.

Modified sprinkler heads of this type were tested quite extensively, mostly over fires in automobile tires piled to various heights, with very gratifying results in improved protection as compared with standard heads. Criteria for improvement consisted of data with respect to actual damage to tires, damage to combustible ceilings, ceiling temperatures, number of heads operated, and total resulting water flow.

After many confirmatory tests, both with combustible and noncombustible ceilings, including semi-mill construction, and with fires in both medium and high head rooms, we were satisfied that we had been able to make a substantial improvement in the effectiveness of sprinkler heads and we concluded that our findings should be brought to the attention of the sprinkler industry without delay so that the manufacturers could continue with further development.

Consequently, we prepared an announcement dated November 13, 1950, outlining briefly the desirable changes in distribution pattern, the resulting improved effectiveness, and supplied a sketch showing a practical deflector design for the improved type of distribution. At the same time, we were convinced that the ultimate performance had not been obtained and suggested in our communication that other designs of even better performance undoubtedly could be developed. The response from the industry has been quite gratifying. Three sprinkler manufacturers have submitted experimental models for actual test; and we are reasonably certain that others are engaged in development work.

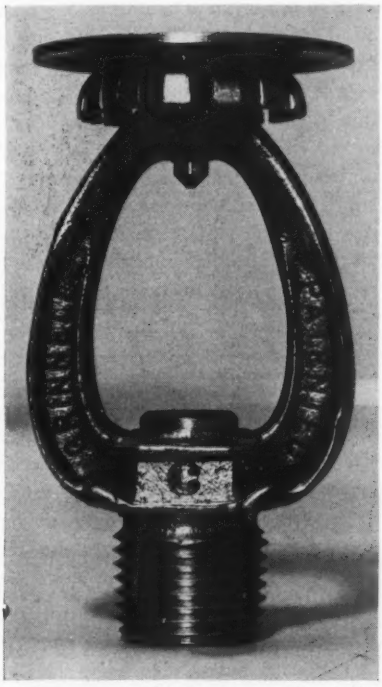


Figure 1. Modified commercial sprinkler used in early tests.

The accompanying Figure No. 1 shows a modified commercial sprinkler head with a deflector appreciably altered from the original and with a superimposed flat round disc to give a generally good distribution of considerable spread below a horizontal plane at the elevation of the deflector. Figure No. 2 illustrates an early experimental model submitted for test by one of the sprinkler manufacturers. This model showed some improvement in performance over those which we had developed independently. However, since the availability of this commercial experimental head, designs even further improved have been submitted and tested under various fire conditions.

How the New Spray Sprinkler Operates

It appears desirable at this point that there be some discussion of the water distribution characteristics of the new type and the reasons for the improved effectiveness.

As the result of all our experimental work with sprinklers and spray nozzles, it is obvious that the most important single factor is to *discharge water at the maximum available rate onto the burning material*. Such an objective can only be obtained with a fairly uniform distribution so as to discharge the most water at any location in which a fire might occur, especially with multiple head operation. It also follows naturally that such uniform distribution should be obtained at relatively high levels below the ceiling as well as at lower levels. Only in such a manner can we expect to

Figure 2. Early experimental model spray sprinkler.

obtain the maximum result in fire extinguishment or fire control.

It is also essential that we accomplish as much as is practical in *cooling the products of combustion* above the fire, especially under the ceiling and around other structural elements so as *to reduce the temperature exposure.*

While we are accomplishing the objective of fire extinguishment or control and protection of the construction, of course, it is most desirable that this be accomplished with the operation of a minimum number of sprinkler heads.

Another factor of importance, although we are unable yet to measure it in any satisfactory quantitative manner, is the degree of atomization or break-up of water discharged from the head. *With good distribution, an improvement in protection is obtained with better atomization* — especially for fires in volatile flammable liquids. However, disappointing results are obtained in spite of good atomization if the uniformity of distribution is poor.

A final factor of obvious importance, *judging from our test work, is the concentration of water vapor and subsequent reduction in oxygen at or near ceiling level.* While this is greater for the new type of head than for the standard automatic sprinkler, it is undoubtedly a factor in protection by either type. This has been demonstrated emphatically in testing both types of heads under joisted construction, in which the protection was much more effective when the joists were fire stopped at 24 ft. intervals instead of being allowed to remain open above the beams for the entire width of the building.

Distribution Characteristics

The general type of distribution afforded by the new type spray sprinkler in comparison with typical standard approved heads is shown on the accompanying graphs (Figs. 3 and 4),—the data in the first one taken with a head operating at a flow rate of 15 gpm., and the second one at 30 gpm.

These graphs show water distribution in gallons per sq. ft. per minute on circles of increasing radius, zero being the location directly under the head. In each case the head deflectors were located 8 in. below a smooth ceiling and the water density was measured 4 ft. below the ceiling.

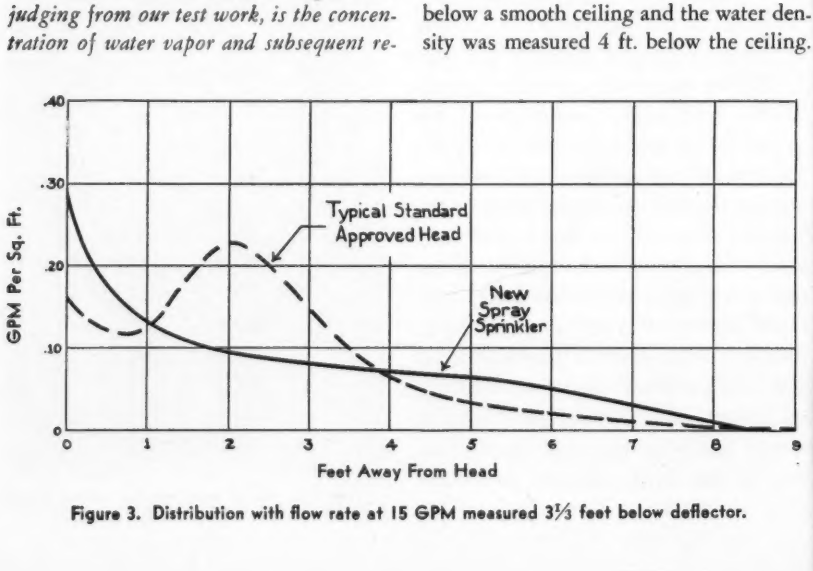


Figure 3. Distribution with flow rate at 15 GPM measured 3⅓ feet below deflector.

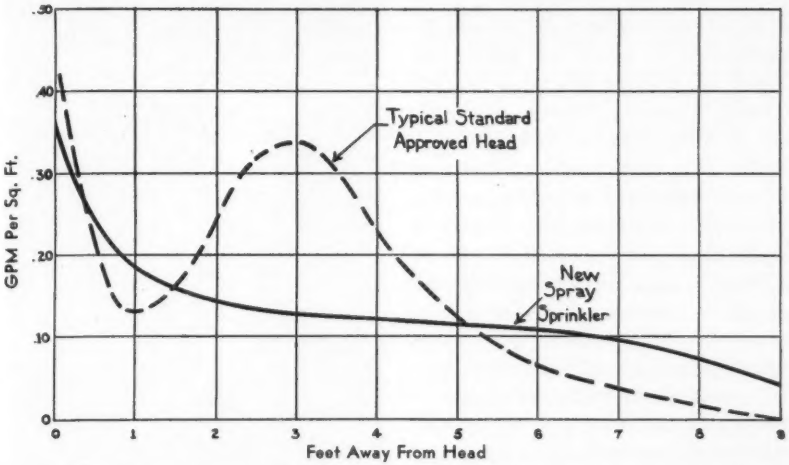


Figure 4. Distribution with flow rate at 30 GPM measured 3⅓ feet below deflector. Note that the new spray sprinkler gives increased density beyond 5 feet and that "hump" at 3 ft. with typical standard sprinkler is overcome.

With the typical standard approved head, it will be noted that there is a decided hump in the 15 gpm. curve at a distance approximately 2 ft. away from the head. This is due mostly to the water which discharges against the ceiling and falls almost vertically therefrom. It will be noted also that the new spray sprinkler gives an inincreased density beyond 4 ft.; or in other words has a greater spread or reach. When the flow rate is increased to 30 gpm., the lateral throw is increased with both types of heads, but again the new spray sprinkler has a much greater discharge density at radii beyond approximately 5 ft.

These graphs show average densities obtained by measuring the discharge throughout the entire 360° on circles of increasing diameter. However, they do not tell one very much about the uniformity on each circle. The new spray sprinkler design is exceptionally good with respect to uniformity; and probably the easiest way to tell the story would be to state that with multiple heads in operation and at a flow rate of 15 gpm. per head, the minimum density anywhere under heads spaced 10 ft. x 10 ft. would be at least 0.10 gal. per minute per sq. ft., except for a very narrow zone in the plane of the sprinkler frame.

We have made several attempts to obtain significant data with regard to relative atomization or break-up. We have tried various methods,—including measurement of reflected light from a standard light beam passing through the sprinkler discharge, and we have taken high speed photographs of thin sections of the discharge. We also constructed a large calorimeter housing in which we attempted to determine the cooling capacity by absorption of heat from a metered air flow at a known elevated temperature. For one reason or another, all of these methods proved unsatisfactory in comparison to temperature measurements obtained in actual fire tests.

Fire Testing Method

One of our greatest problems was the development of a standard fire testing method which might be applied to wood and other ordinary combustible materials, with particular reference to fires in high piled boxed or crated products and to other fires in which some substantial proportion of the combustible might be shielded from direct sprinkler distribution. Although we had already run about 50 large scale fire tests with the new spray head on fires in automobile tires, it seemed necessary in order to save time and to obtain much more consistent results that we develop a more readily duplicable fire. After many preliminary tests, we finally standardized on a crib arrangement of Douglas fir, constructed of 2 x 4's and 4 x 4's, supported by two 4 x 6's above a gasoline fire from a spray nozzle through which gasoline could be discharged at an accurately metered rate.

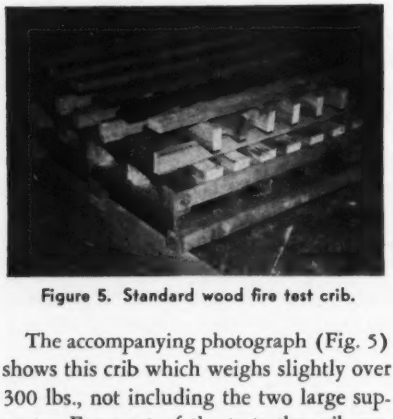


Figure 5. Standard wood fire test crib.

The accompanying photograph (Fig. 5) shows this crib which weighs slightly over 300 lbs., not including the two large supports. For most of the tests the crib was elevated so that its top was approximately 8 ft. below the ceiling. In a series of tests to measure protection with only 3 ft. between the ceiling and the top of the crib, the latter was elevated as shown in the next photograph (Fig. 6). This gives a good idea of the gasoline spray fire and the added flame from the burning crib itself just prior to sprinkler operation.

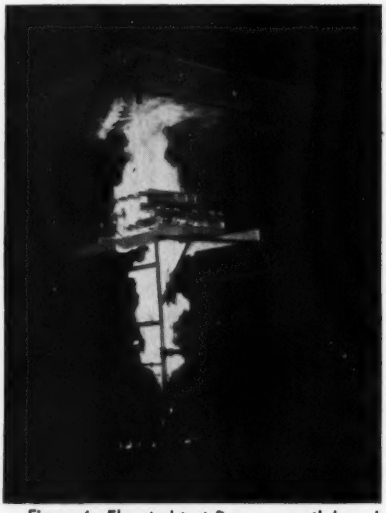


Figure 6. Elevated test fire on smooth board ceiling.

With these facilities, by varying the gasoline flow rate, we were able to involve more or less of the crib in active combustion and to get a good measure of the effectiveness of any kind of protection, even though the gasoline spray flame itself without the crib above would do little or no damage. In every test careful measurements were made of the moisture content of the wood, both in the crib and in the combustible ceiling if used. All fires were run for a total time of 30 minutes.

Our test program in general consisted of adjusting gasoline rates so as to accomplish some measurable ceiling damage with standard approved sprinkler heads at three widely different flowing pressures, namely 5, 15, and 33 pounds per sq. inch flowing pressure on the heads over and close to the fire. Using this general technique, we have

run approximately 170 large scale fire tests.

In tests without the crib, but at greater gasoline flow rates, we have also been able to test the relative effectiveness of various sprinkler deflector designs for fires in flammable liquid or other extra hazardous occupancies.

General Test Program

Our comparative test program to date has included tests of typical approved sprinkler heads versus new spray sprinkler types under non-combustible ceilings, and combustible ceilings of various types of construction—both in high and low elevations. The combustible ceilings included smooth ceilings of matched tightly fitting boards, mill construction with various bay widths of 3, 4, 5, and 7 ft., and joisted construction. Tests were run with head spacing staggered under alternate beams and also located in the bay-beam arrangement. In some cases the tests were run with supporting members fire stopped as they would be if framed into beams, and in other tests with the secondary members resting on main girders or beams without heat stops. We have also run tests with fires originating at the ceiling — particularly in joisted construction. The standard approved sprinklers were installed with respect to the construction according to the present sprinkler rules although we invariably located the standard heads under smooth ceilings with the deflectors 8 in. below the ceiling because we have found out that they operate more effectively than at the closer distances.

The new type of upright spray sprinkler has been tested in comparison at the same spacing with reduced pressure and flow, with reduced orifices resulting in a reduced flow at the same pressure, and also at the same pressure and flow but with spacing increased up to 144 sq. ft. per head. We have also tested the new type of heads, running sprinkler lines across under beams 7 ft. apart in disregard of the rules, and with the heads located so that they would come outside of the bay under which the fire exposure was directly centered.

Summarized Test Results

1. In our so-called Class A fire tests using a combination of a gasoline spray at different rates of flow and the wood crib shown on photograph Fig. 5, the new spray sprinkler was compared to standard approved heads operating at pressures of 5, 15, and 33 psi. and with the fire located 8 ft. below the sprinkler heads, but at various locations laterally with respect to the heads. For comparison, the new spray sprinkler was in each case operated at a discharge rate reduced 25% by dropping the pressure. The test criteria were the damage to the ceiling, the actual weight loss of the crib, the maximum sustained temperature for 5 minutes and the total resulting water flow from the number of automatic heads which opened. On the average, destroyed ceiling areas were reduced from 14 sq. ft. to 0, the crib weight loss from 160 lbs. to 43 lbs., the ceiling temperature from about 1200° F. to 800° F. or less, and the total water flow reduced from 252 gpm. to 192 gpm.

2. In tests in which the new spray sprinklers were spaced 10 x 13⅓ ft. without staggering as compared with 10 x 10 for the standard approved heads, both types operating at the same flow and pressure, the results in all respects were approximately identical to those just given.

3. In fire tests with the crib elevated to a position only 3 ft. below the sprinkler head deflectors, the advantage was even more marked except that the ceiling damage increased from 0 to about 20% of that

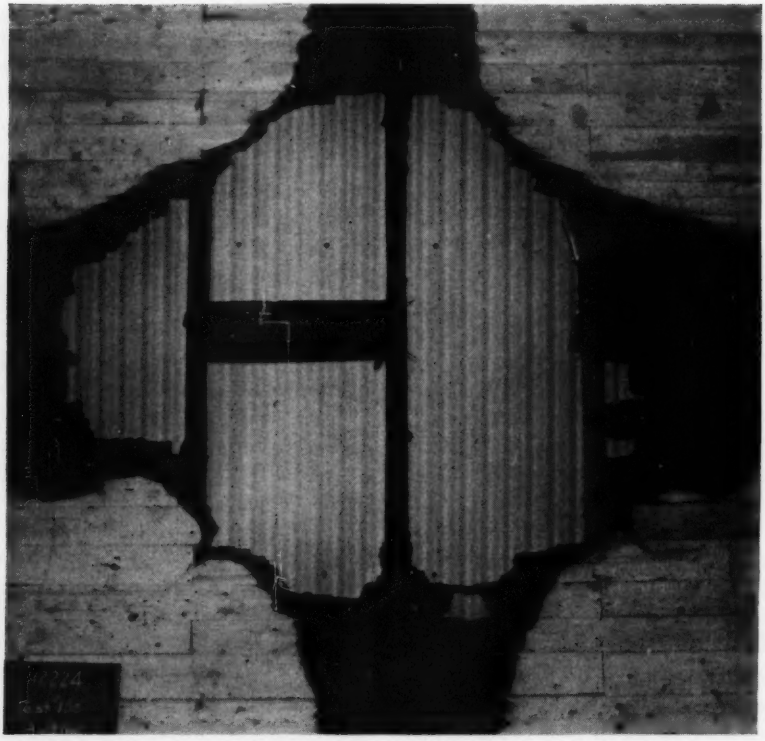


Figure 7a. Damage to smooth wood ceiling (corrugated iron siding shows area of burn-through) after gasoline fire test where ceiling was protected by standard sprinklers at 50 psi.

sustained with protection by standard sprinkler heads.

4. In the tests on semi-mill construction with 3 ft., 4 ft., and 5 ft. bays, ceiling damage was much less even at a 25% reduction in discharge rate from the sprinkler heads, and about the same advantage was maintained with respect to crib weight loss and maximum temperature, but the total water flow at the reduced pressure was about the same as with standard sprinklers at the higher pressure.

5. In the tests on joisted construction in which the heads were placed 7 ft. apart on a line with the sprinkler lines 10 ft. apart and the heads staggered on alternate lines, the improvement in the new type, even at a 25% reduced flow, was even more marked by every criteria than in the tests with semi-mill construction.

6. In a series of tests at varying sprinkler pressures and with fires of different intensities and with the new type of spray sprinkler bushed to give approximately ⅔ of the discharge rate at the same pressure, the bushed head showed an even greater superiority over standard sprinkler heads than it did with the same full orifice but at reduced pressure. Standard approved heads were tested under mill construction with

7 ft. wide bays with the sprinkler lines in the bay and with the heads spaced 11½ ft. apart on centers. The new spray sprinkler bushed to a ⅔ discharge rate was placed on lines 10 ft. apart running under and at right angles to the beams with the heads spaced 9 ft. apart on lines and located outside of the bay in which the fire was centered. Even under these adverse conditions with slightly more area per head, the destroyed ceiling area was reduced from 14 to 3½ sq. ft., the crib weight loss from 156 lbs. to 44 lbs., and the total water flow was approximately the same.

7. Various spray sprinkler deflector designs were compared with typical standard approved sprinkler heads on fires involving gasoline spray only. The standard heads were run at flowing pressures of 5, 15, 33, and 50 psi.; and the spray sprinklers were operated at a pressure to reduce the flow approximately 25%. Even at the reduced pressure and flow, the spray sprinklers maintained their advantage over the standard sprinklers, although the advantage with respect to ceiling destruction, ceiling temperatures and total water flow was less marked than in other comparative

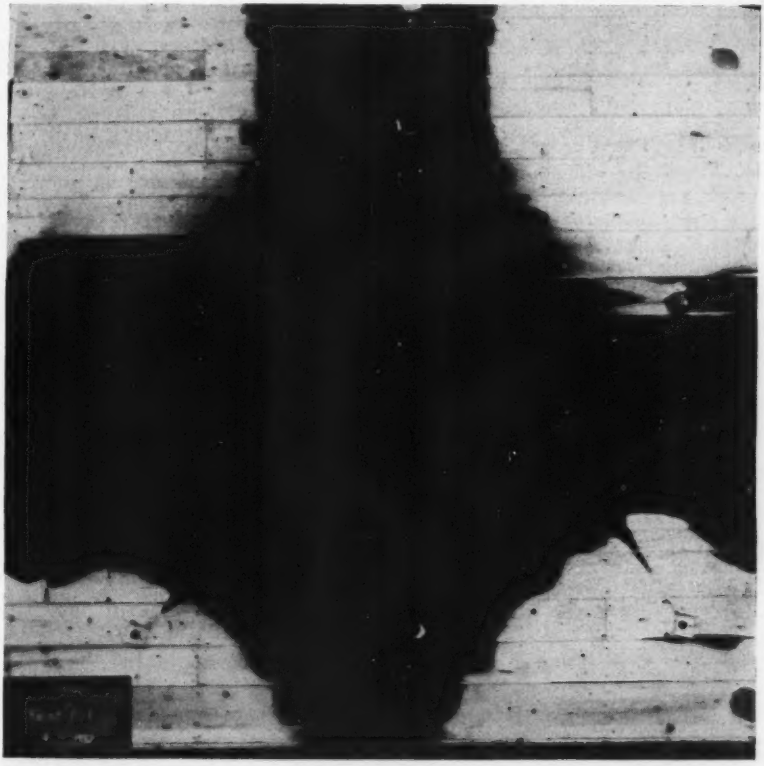


Figure 7b. Damage is lighter to same type wood ceiling as shown in Figure 7a after gasoline fire where new spray sprinklers were used at 28 psi to protect the ceiling.

tests involving ordinary combustible material. In these tests also the benefit from deflectors giving better atomization of the water was evident, particularly with respect to ceiling temperatures and numbers of heads opened.

The protection of a smooth wood ceiling is shown in the accompanying photographs (Figures 7a and 7b), in which the exposure was obtained from a gasoline flow rate of about 2 gpm. with the gasoline spray nozzle approximately 13 ft. below the sprinkler heads. No wood crib was used in these tests. The sprinkler spacing was 10 ft. x 10 ft.; the standard approved sprinkler operated at 50 psi. and the spray sprinkler at 28 psi. Comparative ceiling damages were 7½ sq. ft. and ½ sq. ft., maximum sustained ceiling temperature 1270° F. and 1200° F.; and the total water flow was 440 gpm. and 362 gpm. Regardless of the small difference in ceiling temperatures, it is obvious that the ceiling used in the test with the new spray sprinkler was much better protected — probably in some degree due to the reduced oxygen content in the atmosphere close to the ceiling as a result of the very good high level water distribution. The spray sprinkler design used in this pair of tests was relatively mediocre with respect to atomization.

Tire Fire Under Semi-Mill Construction

Another set of photographs (Figures 8a, 8b and 8c) resulted from comparative tests made under simulated semi-mill construction with beams 5 ft. apart on centers and with sprinkler heads located 10 ft. by 10 ft. with the alternate beam arrangement. The ceiling before the test is shown on the first photograph (8a). These tests were run with our standard 8 ft. high automobile tire pile fire for which we maintained 33 lbs. per sq. in. on the standard heads. The photograph (8b) shows that we destroyed about 45 sq. ft. of the board ceiling and that the 4 x 12 beam was entirely burned through.

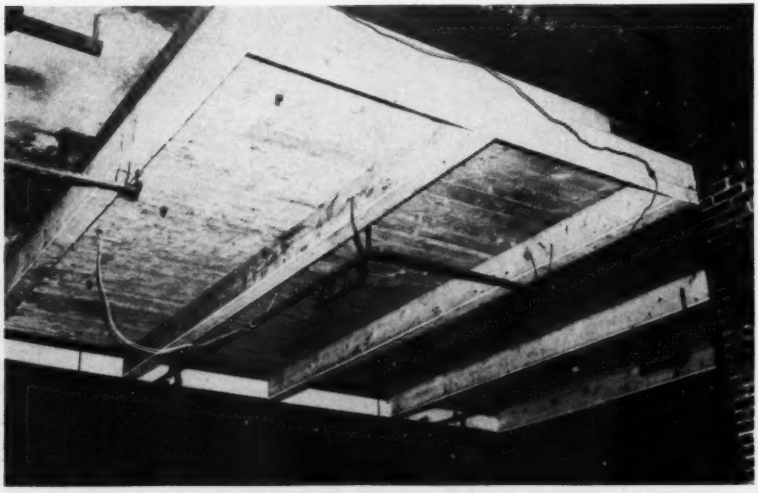


Figure 8a. Narrow bay (5 ft.) and beam wood ceiling before the tests.

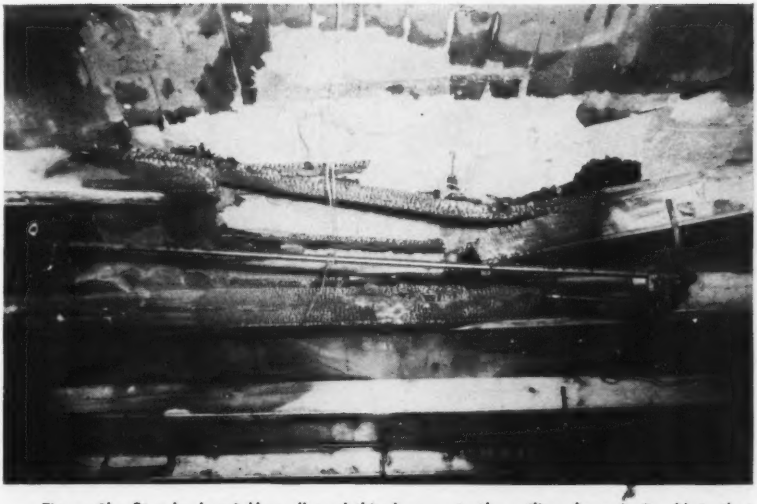


Figure 8b. Standard sprinklers allowed this damage to the ceiling shown in 8a. Note that the 4 x 12 beam was entirely burned through. (Pressure 33 psi.)

In the corresponding test with one of the new spray sprinkler types, the test conditions were identical except that the flowing pressure on the spray sprinklers was reduced to 20 psi. Figure 8c shows only 4 sq. ft. of the ceiling destroyed, the beam was only slightly charred. The tires damaged were the same in both tests.

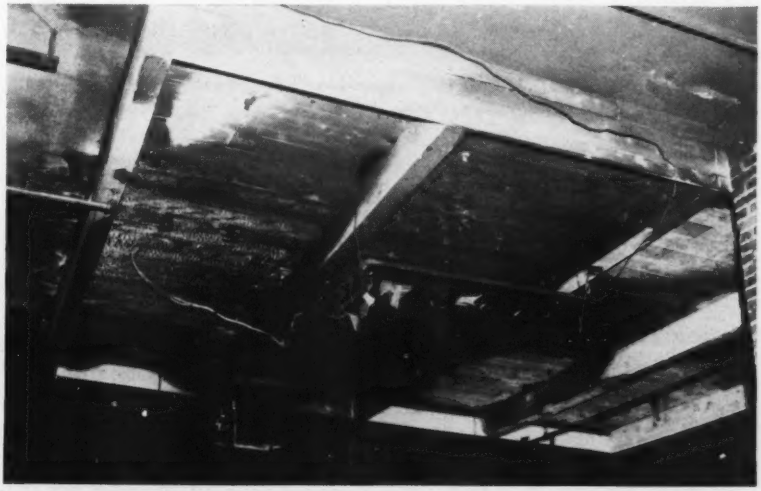


Figure 8c. New spray sprinklers gave this corresponding performance at 20 psi. Note beam only slightly charred.

Figure 9a. Damage area (shown by corrugated iron siding in background) with standard sprinklers on 10 ft. by 10 ft. spacing operating at 5 psi.

Crib Fire, Low Sprinkler Pressure

In order to give an idea of what may be accomplished with the new spray sprinklers over a partially shielded fire in ordinary combustibles at relative low sprinkler operating pressures, Figures 9a and 9b show the comparative effect on a wood ceiling with sprinklers on 10 x 10 ft. spacing with standard approved heads operating at 5 psi. and the new spray sprinkler at 2.7 psi.

The fire exposure was a wood crib such as is shown in photograph (Fig. 5) 8 ft. below the sprinkler heads and with the gasoline spray fire underneath at a gasoline flow rate of 0.73 gpm. With the standard head at 5 psi., the burned out area of the ceiling was approximately 8½ sq. ft., the crib weight loss 150 lbs., the sustained maximum ceiling temperature 1000° F. and the total water flow 217 gpm. With the new spray sprinkler operating at 2.7 psi., the ceiling damage was almost nil, the crib weight loss 25 lbs., the maximum sustained temperature under the ceiling 620° F., and the total water flow 124 gpm.

Figure 9b. Protection afforded by new spray sprinklers operating at 2.7 psi is obvious from this comparative illustration to Figure 9a.

Application of Spray Sprinklers

The first obvious use for the new spray sprinklers is a replacement for the present standard approved sprinkler in locations where the fire hazard approaches the limit of ordinary sprinkler capacity or where the water supply is somewhat scant. Superior protection will be obtained with a given water supply with the same number of heads operating; and equal protection can be obtained with a greater number of heads in operation, even at substantially reduced flowing pressure. Such a substitution can be accomplished at considerably lower cost than any other available method for improving an existing sprinkler system.

A second use which suggests itself is a substitution for standard approved heads of the new spray sprinkler with an orifice to decrease the flow rate approximately $\frac{1}{3}$ *or possibly more at the same pressure.* If this is done, the protection will be at least equal in the event that only a few heads operate, but if because of unusual conditions an excessive number of heads are opened, then the effectiveness of protection increases considerably over that from standard sprinkler heads with the same

water supply, on account of the reduction in friction loss through cross mains and branch lines. This possible use of the new type of distribution would be particularly advantageous for occupancies, such as cotton storage or manufacturing where large numbers of heads may be opened, but where the fire severity is relatively low. The use of the new type of spray sprinkler with a reduced orifice but with standard pipe sizes and spacing schedules has an additional advantage in that, if the fire hazard of the occupancy should later increase, the protection can be reinforced with spray sprinklers of normal ½ in. size with no changes to the piping system. One disadvantage in the use of reduced orifice sprinklers is the difficulty of identification and recognition after installation.

New sprinkler installations can be made at considerable reduced cost if the new spray sprinklers in ordinary orifice size are spaced further apart allowing greater protected area per head, such as 25 to 33% more. For occupancies of ordinary hazard, this would be the most economical application, particularly when there is a reasonable assurance that the fire hazard will not be increased subsequently. For relatively light hazard occupancy such as office buildings, there seems to be no good reason why the new type of spray sprinklers cannot be installed up to spacing distances of about 12 ft. x 12 ft.

Regardless of orifice size or spacing, however, there are some general features of the new type of sprinkler worth mentioning. For example, there appears to be no good reason why sprinkler lines cannot be run at right angles to beams in mill construction, neglecting beam spacing altogether for narrow bays. However, we do not believe that sprinklers should be placed further below the ceiling than is now allowed for standard sprinklers; and it would also appear advisable to stagger the spacing of heads on alternate lines wherever practicable.

Since the new spray sprinklers have a much wider distribution pattern or a longer lateral reach than the present standard type, there is always a good chance that they might stop a slowly spreading fire such as in textile manufacturing occupancies with a lesser number of heads opened than the standard type with its more restricted distribution. For the same reason there will be water discharged onto a fire beneath a plugged head on account of the distribution range of surrounding heads.

On the subject of general rules for installation of the new type of sprinklers, we have not yet reached any final conclusions although our group responsible for fire protection engineering standards is giving the matter intensive consideration. At the present time, we certainly can accept the new spray sprinklers in place of the present standard type on at least an equal basis with the credit or advantage to be determined more exactly at a later date.

LP Gas Bus Fueling Station, San Antonio*

By Hugh V. Keepers

Increasing use is being made of liquefied petroleum gas, primarily propane, as a motor fuel by transit companies, large trucking concerns, and other vehicle fleet operations. The fuel has been widely used for motor vehicles on the Pacific Coast, but LP gas is now being adopted in other areas where the gas is readily available at a nominal cost.

Pros and Cons of LP Gas As a Bus Fuel

There are a number of distinct advantages in the use of LP gas as a motor fuel and there are also a number of disadvantages. Since the writer is more familiar with the operations of the San Antonio Transit Company than others, this company's operations will be used as the basis for this discussion. The company carefully considered all of the pros and cons before adopting propane as a motor fuel. Some of the advantages are: fuel saving, reduction in maintenance of motors, and the ability to utilize more efficient high compression engines.

The fuel cost will vary according to locality but has been found in the experience of the San Antonio Transit Company to be about 35 per cent less than liquid fuel at current prices. Where large quantities of fuel are used, this is a primary consideration in changing from liquid fuel to propane as a fuel saving alone might be expected, under normal conditions, to pay for the storage installation in a relatively short time. However, other factors are of considerable importance in the economics of LP gas as a motor fuel. For example,

*Based on a talk presented at the 1952 Annual Meeting of the NFPA, held in New York, June 9-13. (Program Item 50.) Mr. Keepers, a member of the Society of Fire Protection Engineers, is Assistant Manager of the Fire Prevention and Engineering Bureau of Texas (Member, NFPA).

Studers

Bus parking area. LP gas storage facilities are located in the bus parking area. Distances to buildings and property lines are at least twice the minimum distances required by NFPA Pamphlet No. 58. A 2 ft. by 2½ ft. reinforced concrete wall prevents vehicles from rolling or being driven into the tanks and piping.

maintenance of equipment is a major factor in any large transit operation. The average time which overhaul periods can be extended has been found to be, in general, about 50 per cent. In other words, where a bus motor is normally overhauled at the end of each 100,000 miles, this might be extended to 150,000 miles with an LP gas fuel system, which permits more time in service for the vehicle.

Another favorable economic factor is the reduction in the amount of oil used for lubrication purposes. It has been found by experience that the drain period might be extended from about 3,000 miles with liquid fuel to 12,000 to 18,000 miles with propane as a fuel. When it is considered that several hundred vehicles are in use, this would amount to a considerable quantity of lubrication oil over a period of time.

Another advantage is the ability to utilize high compression engines, that is, those with compression ratios in the 10 to 1 class, which are considerably more efficient than those of lower compression ratios at present in use with liquid fuels.

The principal disadvantage in the use of LP gas as a fuel is the first cost of the installation of the bulk storage facilities. This is a very large factor in the overall cost and one which must be approached with considerable caution. However, it has been shown that where the operation is of sufficient size, the cost of the storage installation can be amortized in a relatively short time by the saving in fuel alone. It is sometimes difficult to locate the storage and dispensing facilities for LP gas as there are often zoning restrictions on the installation of such facilities and the fire authorities having jurisdiction may limit the storage and specify clear distances to the line of adjoining property in heavily populated or congested areas. Most of these restrictions are designed to assure that exposure hazards will not create a hazard to life and property safety in event of the release of the gas from any cause. In many cases finding a suitable location for storage and dispensing equipment will determine the feasibility of converting or purchasing new equipment using LP gas as a fuel. Some cities, having congested business and industrial areas might not have reasonably convenient locations for such storage and servicing equipment.

The San Antonio Transit Company was faced with this problem but solved it by finding a suitable open area (a former baseball park) adequate in size for the storage tanks, the dispensing equipment, repair garages and bus parking and they incorporated an additional measure of safety by the provision of a standard water spray system to protect and isolate the various facilities in case of a fire. Facilities can often be located conveniently in suburban areas near usual terminal facilities.

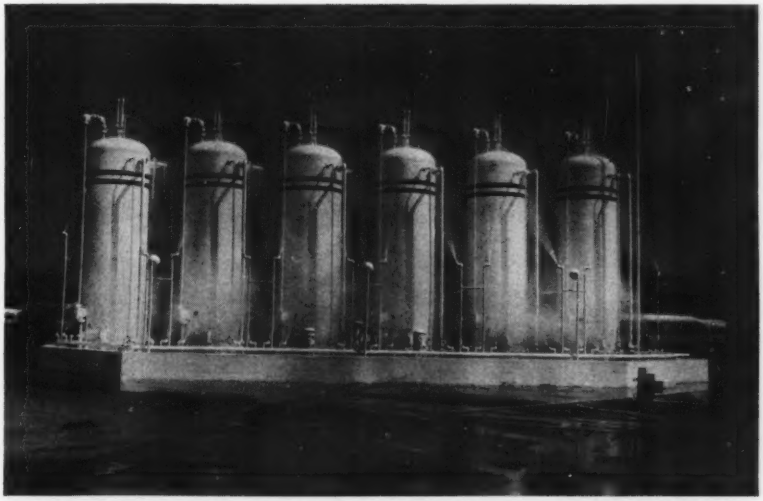
Cooperating Organizations

When the officials of the San Antonio Transit Company approached the Fire Prevention and Engineering Bureau of Texas on the subject of this installation, very little was in print which applied directly to the problems presented. The NFPA LP Gas Standard (Pamphlet No. 58) at that time contained little information regarding this particular type of operation except for a few suggestions relative to the use of the gas in property-carrying motor vehicles. Since the transit company's problem was quite different, there being a considerable life hazard involved, we immediately contacted other people who were experienced in the use of liquefied petroleum gas and bus construction.

Mr. G. M. Kintz, Chief, Accident Prevention and Health Division, Region VI, Bureau of Mines, and his staff were most helpful in advising on this installation and were active in its final inspection and test. Underwriters' Laboratories, Inc. was very cooperative in furnishing much valuable data on LP gas equipment suitable for use on the vehicles. The transit company, through Mr. J. H. Powell, Research Engineer, contacted many other companies with like operations to obtain information on their experience with LP gas. The Twin Coach Company, who manufactured many of the buses used by this transit company, was most interested in a safe and satisfactory installation and worked closely with all interested in the project. Since many of the existing gasoline fueled buses were to be converted to the use of propane, this conversion introduced very definite problems. Insofar as possible, standard conversion kits were obtained from the original manufacturer of the vehicles. For the most part, these conversions have proven satisfactory with the exception of some minor difficulties. These were readily overcome, and at the present time no difficulties are being encountered.

Fuel Storage Installation

Any storage installations for fleet bus operations should conform in all respects to the regulations as promulgated in NFPA Standards for the Storage and Handling of Liquefied Petroleum Gases (Pamphlet No. 58). Additional safeguards may be required where the installation might endanger heavily populated or congested areas (see Par. B.5 (c) of NFPA Pamphlet

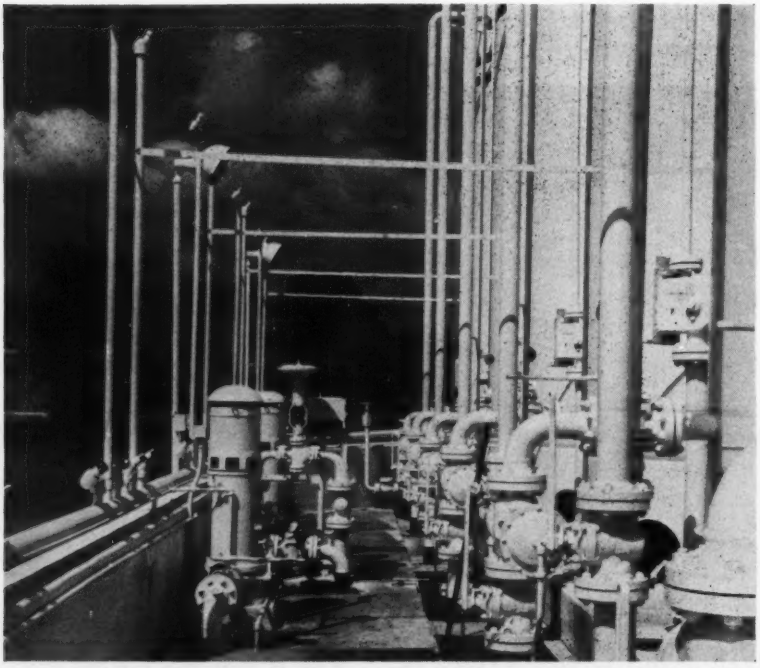


Storage facilities. Among the safety features are: (1) excess flow valves at all openings except safety relief openings; (2) automatic operation of safety relief valves at 250 psi; (3) equipment to test excess flow valves at periodic intervals; (4) remote control air operated valves at suction openings to seal off tanks in cases of fire; (5) spray nozzle at the top of each valves at suction openings to seal off tanks in case of fire; (5) spray nozzle at the top of each tank to operate automatically in excessive solar heat; (6) manually operated 1000 gpm water spray system; (7) all piping special pressure pipe with welded or flanged joints; (8) all electrical equipment explosion proof.

No. 58). The installation of the San Antonio Transit Company's bulk storage was made in accordance with Pamphlet No. 58, and in addition, distances to the nearest buildings and property lines were doubled. (While the facilities were located in a built-up residential area of the city, the storage tanks were located in the center of the old baseball park bought by the San Antonio Transit Co.)

The tanks are six in number, of 5,000 water gallons capacity each, and installed aboveground in a vertical position. This total capacity was necessary to assure a constant supply of fuel for vehicles in case there should be any unusual delay in obtaining shipments. At present, about one-half of the 300 vehicles of the transit company's fleet are propane equipped. When all are equipped to burn the gas, this capacity will be sufficient for about three days' supply.

The company was most cooperative and anxious that this installation be as safe as possible, both from the standpoint of personnel occupying the vehicles and those who reside adjacent to the storage and dispensing facilities. The storage tanks and piping are of standard design and are well installed. A heavy reinforced concrete dike or barrier was provided in order to prevent a bus from colliding with the tanks or piping which might cause a rupture, escape of gas and, possibly, a fire. All valves at



Close-up of Storage Tanks. Note the water spray nozzles mounted above protective wall and on elevated pipes. Each tank has a 5,000 water gallon capacity. Tank shells are .687 inch steel with .550 inch steel heads. Safety relief valves will operate automatically if pressure reaches 250 lbs. per square inch.

Studers

Bus fueling station. Excellent air circulation at this station facilitates rapid dispersion of accidentally released gas. Concrete bumper posts are installed to protect dispenser units and pipe risers. A manually operated 1000 gpm water spray system projects both from the floor and from the ceiling. Each passageway is equipped with static drains which contact an unpainted plate in the top of the bus. Excess flow valves are provided at dispensing meters. Air is sampled continually by a flammable gas indicator.

the suction opening of each tank are air operated and may be operated from remote control locations so that the tanks can be sealed-off without close approach in case of fire. All other piping and valves are as required in Pamphlet No. 58 and in addition, the pressure relief valve employed is of a type which can be removed for testing or can be tested in place without interfering with the general operation of the system.

All pipes to and from the tanks are laid in a concrete trench but are not rigidly fastened to concrete foundations at any point. This allows considerable movement due to any temperature variations without rupture of the piping. The tanks are equipped with a manually operable, special water spray system installed by the Hudson Engineering Company who also installed all the LP gas equipment. NFPA Standards for Water Spray Systems (NFPA No. 15) was used as a guide in the installation but because a special nozzle was used, Mr. Kintz and the writer adjusted the nozzles and established the distances of the nozzles from the tanks being protected. This system discharges one-quarter-gallon of water per-minute per-square-foot of the entire surface area of the tanks and piping, meeting the minimum specifications for control of fires involving gases of this type suggested in NFPA No. 15.

In addition, to maintain normal operating pressures within the tanks during the hot summer months, automatic spray nozzles are installed at the top of each tank. These nozzles are actuated when the pressure in the vessel approaches a predetermined setting (below the pressure relief valve settings on the tanks) and cool the tanks.

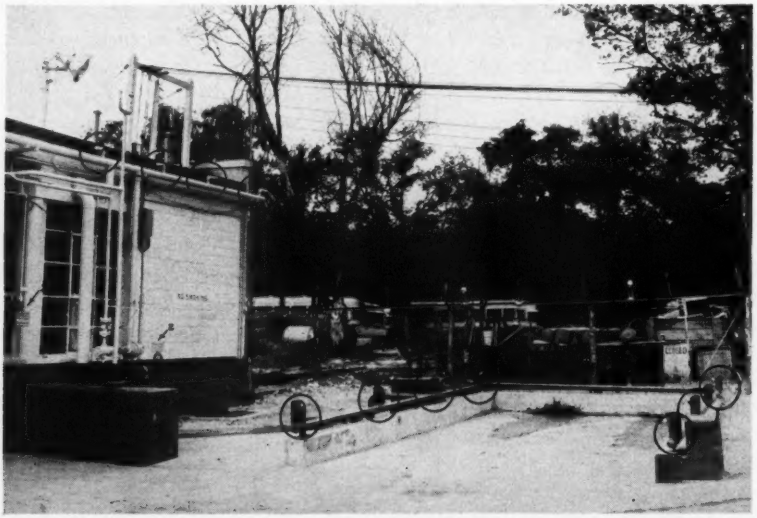
Filling Station

The same filling station which is used for servicing gasoline powered vehicles is used for servicing propane powered units. The station is a type that permits excellent

air circulation and is generally considered of a type most desirable. Some changes were necessary in the use of this structure to service propane buses, primarily a new type of dispenser and some provisions for the protection of dispensers should a bus get out of control. This was solved by the installation of heavy reinforced concrete blocks in front of each dispenser unit. The station is equipped with a manually operated water spray system projecting both from the floor and from the ceiling. This system was used in one case when a gasoline powered bus was involved in a fire during filling operations. The system was operated immediately and the fire extinguished with little or no loss. In addition, each passageway is equipped with static drains which contact an unpainted plate set in the top of the bus body. This static drain has proven very satisfactory in use and frequent tests were made after its installation to determine whether such a system would be practical for this purpose.

Bulk Unloading Station

The propane truck tank unloading station is located at the same point as that used for gasoline unloading, that is, immediately adjacent to the filling station. While this is not considered the best arrangement, it is felt that it is satisfactory in this case as the transit company does not unload tank vehicles at the same time they service buses. The unloading time is relatively short and infrequent and should not interfere with the normal operations of the station. The unloading is accomplished by differential pressure using a compressor to initiate the differential between the storage



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Transport unloading station. A manually operated water spray system is designed to cover the under sides as well as the tops of tank trucks, and also provides a water screen between the unloading area and adjacent fueling station. (Circles show location of the visible nozzles.) Air at the location is continually sampled by a flammable gas indicator. Sign at #1 reads: "Open valve for emergency shut down of propane service" and sign at #2 reads: "Ground truck before connecting delivery hose."

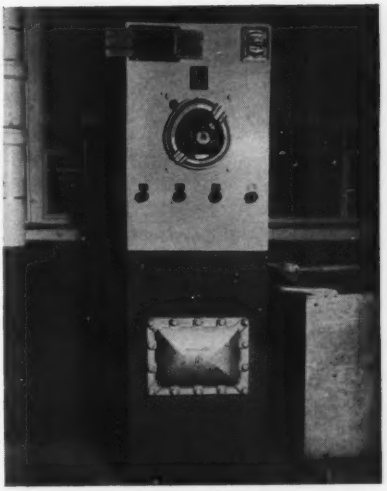
vessel and the tank truck being unloaded. The original installation did not utilize this method of unloading and some difficulty was encountered. The presently adopted system, it is felt, will be much more satisfactory and much safer. The unloading point is also protected by a water spray system (manually operated), covering the under sides of the tank trucks as well as the top portions. It also provides a curtain of water spray between the vehicle and the filling station.

Gas Detectors

In addition to these protective features, at the storage tanks, in pipe trenches, at the filling station and bulk unloading rack, and at several other strategic locations where gas might escape, automatic continuous flammable gas detectors are provided. One or more "sniffer" units located in each of these spots are connected to a standard Mines Safety Appliances Company explosion-proof flammable gas detector. There is, in addition, a similar unit connected to detectors in the four repair pits in the main shop building over which propane equipped buses are serviced. These detectors give immediate alarm to the operating personnel should gas be in evidence in any of these locations. All pits are equipped with a mechanical ventilating system.

Inspection Program

The plant safety engineer, Mr. Ben Glaze, has developed a very complete and comprehensive inspection and testing program which has been in operation for about a year and a half. All valves, including relief valves, are tested on a regular program. It is felt that the lack of operating difficulties has in a large part been due to the diligence of the personnel operating the testing and inspection program.



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Flammable gas indicator. Flammable gas "sniffers" are located at the storage tanks, pipe trench, service station, truck unloading station and at several other strategic locations. These devices continually sample the air at their locations and if a trace of propane is present, actuate an audible signal.

Bus LP Gas System*

In addition to the safety features incorporated in the storage and dispensing facilities, extensive protection has been included in the bus propane system. Fuel tanks are of 0.215 in. boiler plate steel to protect against collision damage. All tank valves are located in an indented well on the side of the tank and do not protrude where they might be knocked off. The vapor valve and the pressure relief valve are protected by a half-inch steel collision plate. The vent from the pressure relief valve is carried to above the bus roof. An integral "outage" or expansion tank incorporated in the fuel tank makes overfilling

*Safety Features of the LP gas system on buses were furnished by the San Antonio Transit Company.

Courtesy San Antonio Transit Co.—Studers

Fueling a Propane Bus. Fuel compartment door is connected to a microswitch so that when the door is open (as shown in the photo) the starter circuit is opened. This prevents bus being driven away with hose still in tank.

impossible. Liquid and vapor outlets of fuel tanks are protected by excess flow valves. A solenoid valve in the fuel line to the engine and actuated by ignition current cuts off liquid and vapor lines when the ignition is turned off. The fuel tanks, regulators, filters and carburetor are located in compartments not communicating with the passenger space to prevent any escaping propane from reaching the passenger compartment in case of accidental leakage.

Bugs and Their Elimination

As in all new types of installations, "bugs" can be found and even though every effort was made in the initial planning and engineering of this installation, some of these "bugs" did occur. However, they primarily involved personnel. For example, it was found that during servicing operations, hostlers* would sometimes leave their vehicles to obtain water or cold drinks and would get back on the buses and drive off with the propane filling hose still connected to the tank. This resulted in the breaking of a number of rupture rings on these nozzles and the spilling of a small amount of gas before the excess flow valves operated. After several such occurrences, it was decided to install a small microswitch in the starter circuit which would automatically open the circuit when the tank compartment door was opened. With this safety provision, it is impossible to start the motor until the hose has been removed and the tank compartment door closed.

Another problem was the difficulty operators had in starting buses on the initial run each day. Each tank is equipped with a shut-off valve operating from the ignition circuit with the valve located at the supply tank. Sometimes in starting a bus

*"Hostlers" are employees who drive buses within the storage and servicing areas.

after an idle period, the first surge of gas through the supply line would operate the excess flow valve with the operator being unaware of what had happened. The result was that the battery would soon become exhausted and the bus could not be started. The company solved this matter, at least as far as their operations are concerned, by the installation of an additional valve at the pressure regulator which, when opened, will give a sufficient amount of gas to start the bus upon actuation of the starter.

A third operational problem was that of buses exhausting their supply of fuel while on a run. The only solution appeared to be the use of a small auxiliary tank which would be carried to the helpless bus, which could then be returned to the station for a full load of fuel. However, some objection has been made to this by the fire marshal, with the result that the buses are at the present time towed back to the station. It is felt that some better solution can be found for this problem since towing vehicles introduces an accident hazard. Perhaps a small auxiliary tank inserted beneath the bus in a protected manner could be used rather than the present method of towing the buses.

It is felt that the San Antonio Transit Company has done much to provide safety in the use of liquefied petroleum gas as a motor fuel. Their approach to the problem was an excellent one, and the cooperation of the company and all other interested parties is an example of what can be done to bring about a successful solution to a difficult problem. There may be points in the operation which experience will show can be improved upon. If so, then when these points are brought to light, we can further improve the general situation concerning the use of liquefied petroleum gas as a motor fuel.

Million Dollar Pier Fire, Vancouver, B. C.*

The pier and grain conveyor galleries of the National Harbours Board Elevator No. 3 at Vancouver, B. C., were destroyed by fire on April 23, 1952. The manner of spread and degree of destruction was not unusual for fire involving an unsprinklered combustible pier. The striking feature was the relatively minor damage suffered by two pier warehouses and the substructure of a second pier, owned by Buckerfield's, Ltd., parallel to and practically adjoining the National Harbours Board pier.

An automatic water curtain, sprinklers in the warehouses and beneath the pier deck and fireboat hose streams were primarily responsible for saving the Buckerfield property. Two freighters berthed at the National Harbours Board pier were removed before being extensively damaged. Total loss was estimated at $1,370,000.

Pier Layout

National Harbours Board Elevator No. 3, in the heart of the Vancouver waterfront, consisted of two banks of concrete storage bins 100 ft. high (see diagram) with a fire-resistive workhouse and attendant buildings between. The overall length of the banks of storage bins was approximately 800 ft. Adjoining on the west side of the workhouse was a 4,000 sq. ft. two-track noncombustible receiving shed (No. 1) with concrete floor and foundations. The

*Based on reports submitted by the British Columbia Underwriters' Association and the Vancouver Fire Department.

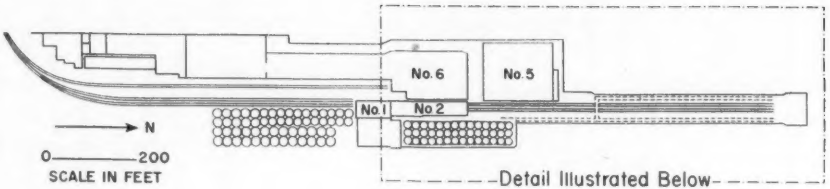
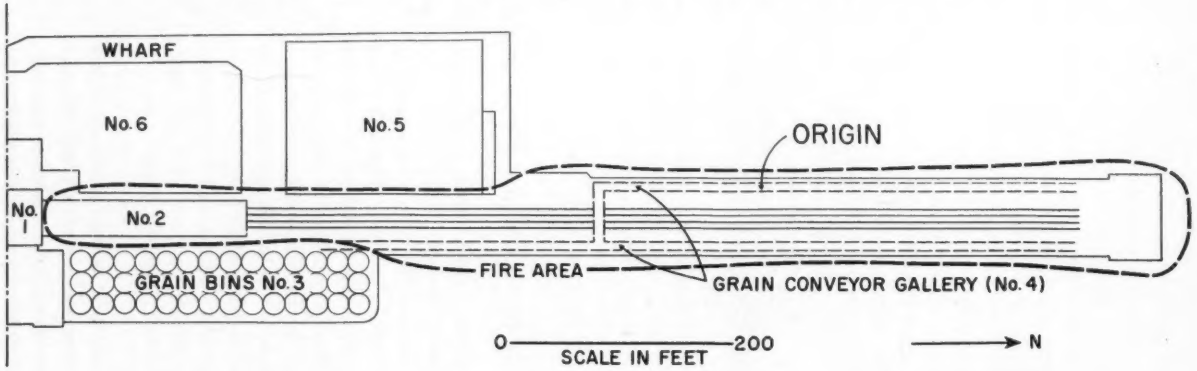


Diagram of National Harbours Board Elevator No. 3 at Vancouver, B. C.



The North end of this pier extends to deep water, the south 350 ft. is over land, partially under water at high tide.

pier, of heavy timber construction and supported by creosoted piles, extended approximately 1,000 ft. northward from the receiving shed. The south 350 ft. of the pier was over land partly tidewashed. An auxiliary track shed (No. 2) of wood-frame, metalclad construction extended approximately 150 ft. northward along the pier from the north end of the receiving shed. Wood-frame, metalclad conveyor galleries on timber trestles (No. 4) extended along both sides of the pier its full length.

The exposed portion of the Buckerfield property consisted of a 28,500 sq. ft. freight shed (No. 5) and a 23,000 sq. ft. warehouse (No. 6), the latter used for storage of roofing material, fuel and fertilizer. Both 1-story buildings were constructed of wood framing with ironclad exterior wall covering over 1-inch boards. These buildings were located on a pier adjacent to the south part of National Harbours Board Elevator No. 3 pier. Only about four feet clear space separated the east side of Building No. 6 from Building No. 2, and only two feet separated the east side of Building No. 5 from the uncovered portion of the Harbours Board pier.

Private Fire Protection

Protection for the Harbours Board pier consisted of four 6-inch hydrants suitably distributed along the pier and supplied by an 8-inch main (northernmost 350 ft. 6-inch). Water was supplied to the pier main from an 8-inch circulating city main 1,000 ft. to the south.

Buildings Nos. 5 and 6 at Buckerfield's were protected by three dry pipe sprinkler systems providing complete coverage below the roofs and floors of both buildings and providing exposure protection along the east wall of No. 6 by means of a line of outside sprinklers. Connection to a 6-inch city main and to the 8-inch main on the adjacent Harbours Board pier provided two sources of supply for sprinklers. The latter connection was made below the pier, with piping, check and gate valves protected against freezing by sawdust-filled boxing and suspended by hangers from platform timbers. During the fire, sprinkler protection for Buckerfield's was seriously jeopardized when the boxing and hangers collapsed leaving piping and valves without support for a distance of 20 ft. A serious loss of water did occur early in the fire when pier collapse snapped the hydrant supply main. Since the gate valve on the pier main could not be located until the fire was out, water supply from hydrants south of the break was poor thereafter, but since sprinklers were supplied from two sources water for sprinklers remained adequate.

The Fire

On the morning of April 23 repairs involving the use of electric welding equipment were in progress aboard the 10,000-ton freighter *Vinni,* berthed on the west side of the Harbours Board pier. A portable gasoline-driven generator built for use in narrow locations had been stationed on the wharf as close as possible to the stairway to the ship and about 350 ft. from the north end of the pier.

The fire broke out when an 18-car freight train being moved northward on the west track of the pier came in contact with the generator. The 10-inch clearance between the generator and train appeared to be adequate but as the fifth car passed, the generator was caught, thrown against the sixth car and crushed. The ten gallons of spilled gasoline ignited immediately

The North end of this pier extends to deep water, the south 350 ft. is over land, partially under water at high tide.

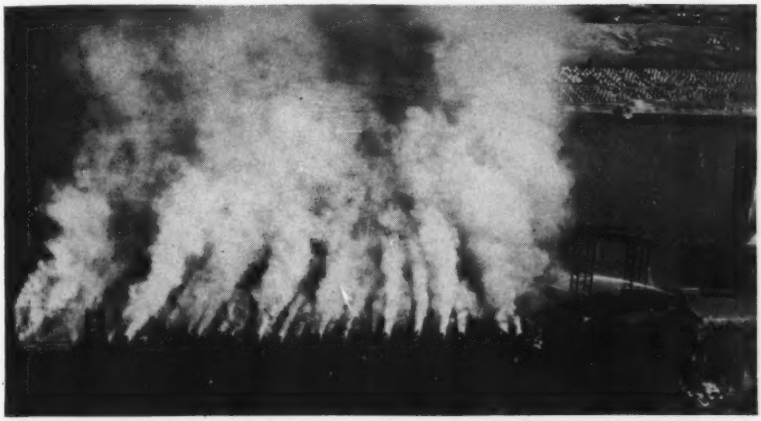
(possible ignition sources included the hot manifold of the generator or an electric spark), flowed through openings in the pier deck, and ignited the creosoted timbers and joists below.

The alarm was telephoned without delay from both the pier office and ship at 11:35 A.M. but because of the great rapidity with which the fire spread, a large part of the pier including the grain conveyor galleries was already involved when the first apparatus arrived. Second and third alarms were struck at 11:42 A.M. and 11:47 A.M.

Hose lines were laid from the southernmost hydrants and streams were directed northward from positions on the east side of Building No. 5. However, because of the dense smoke and intense heat being driven southward by the northeast wind firemen were unable to hold this position, and after retreating and making a brief stand at No. 2 they dragged their hose lines rapidly southward with the help of a truck.

Coincident with the attack from the pier, firemen and Buckerfield employees had laid several hose lines over the roofs of Nos. 5 and 6, and with the assistance of outside sprinklers on No. 6 were protecting the east walls of these two buildings until heat and smoke drove the men from No. 5. Fortunately, the Vancouver fireboat made a timely appearance northwest

View of Vancouver, B. C., pier fire of April 23 taken from southwest of pier. Fireboat streams being directed across the northern corner of Building No. 5 effectively protected that building and cut down the fire on the pier.



Acme

The 1,000-ft. long pier at National Harbours Board Elevator No. 3, Vancouver, B. C., was destroyed by fire on April 23, 1952. Although the fire was discovered promptly, lack of fire stops allowed wind to drive flames through most of the pier before apparatus arrived.

of Buckerfield's at this moment and by directing streams across the northeast corner of No. 5 effectively cut down the fire. Fire in the track shed (No. 2) ultimately drove firefighters from the roof of No. 6, but the fireboat was relocated farther south so that hose and monitor streams could be brought to bear on No. 2, and by 2:30 P.M. the fire in this building was under control and further southward spread was checked. The value of the new Vancouver fireboat (dubbed by some when recently purchased as the "white elephant") was clearly demonstrated at this fire. Complete extinguishment of the remaining fire in the substructure of the Harbours Board pier was accomplished by hose streams directed through holes cut in the east walls of Nos. 5 and 6. In all, 17 pieces of apparatus, 37 hose lines and 264 firemen were used to control the fire.

Damage

The Harbours Board pier and galleries were practically a total loss and the track shed (No. 2) was extensively damaged but still intact.

Of particular interest was the relatively minor losses suffered by the severely exposed Buildings Nos. 5 and 6 at Buckerfield's. Several sheets of metal siding of the east wall of No. 5 became detached and the wood sheathing was charred. However, damage was on the outside only as sprinklers below the roof and fireboat streams combined effectively to protect the interior of the building. Although the east wall of No. 6 was severely damaged by the exposure fire in No. 2, outside and inside sprinklers kept interior damage to a minimum. Charring of ceiling joists inside No. 6 offered a graphic illustration of the limitation of water distribution when heads are placed directly below joists.

Automatic Fire Detection for the Home*

By W. G. Holmes

Nearly half of all the fire deaths in this country occur in dwellings where occupants, while sleeping upstairs, are trapped or suffocated.

Let us consider a few examples. Here is a clipping from the Boston *Herald* of February 24, 1948.

"A Cambridge manufacturer, his wife and their four children perished early yesterday morning, when fire destroyed their 16-room home at 48 Brewster Street, Cambridge. The family maid, who jumped 30 feet from her third-story room, was in grave condition last night at Cambridge City Hospital.

"Dead in the blaze, in which six firemen were injured, were H. Alan Gregg, Jr., 37-year-old treasurer of Hall-Gregg, Inc., his wife, Mrs. Anna (Ten Broeck) Gregg, 35, and their children, Susan, 9, H. Alan 3d., 8, Peter, 3, and Thomas, 10 months. Gregg, Harvard Graduate, Class of 1935, was the son of H. Alan Gregg of Nashua, N. H., one of the State's wealthiest men, and a former Nashua Police Commissioner."

Actually the house was not badly damaged, as you see from the post-fire photograph published here. It is structurally sound externally, was rebuilt and later reoccupied with relatively small expense. Let's see what else is said about this fire.

*Based on a talk presented at the 56th Annual Meeting of the NFPA, June 9-13, 1952. (Program Item No. 75.) Mr. Holmes, an Associate Member of the Society of Fire Protection Engineers, is Secretary of the Automatic Fire Alarm Association (NFPA Member).

Charles L. Hanson, Jr.

The Gregg home, discussed in Mr. Holmes' article, following the tragic fire which caused the death of all six members of the family. All occupants were trapped by smoke on the second floor before they were aware of the fire which started from a spark by-passing a fireplace screen in the downstairs living room.

Ronnie Nelson—Memphis Press-Scimitar

A two-year-old baby was heroically rescued from this blazing home thanks to the chance detection of a neighbor driving by. The fire, occurring Jan. 19, 1950 was believed caused by faulty wiring.

"In the bedroom over the fire, the mother and ther and nine-year-old daughter were lying the floor. The child was by the father, and e mother was over by a side window. They ere not burned. Medical Examiner Dr. David ow later said all had died of suffocation, and at only Peter, three years old, had been burned out the face and arms. Susan and Peter had ept in the right front bedroom, Mr. and Mrs. regg in the right rear bedroom, H. Alan the . in the left front, and Thomas, the baby, in e rear left bedroom."

In other words, they were well distrib- ed about the second floor of a medium zed two-story residence.

"Firemen believed Susan had been awakened smoke and flame and had run to her parents' om to rouse them. Then, they said, the three ere overcome as they set out to rescue the her children. Susan, firemen said, looked as ough she had been dropped from her father's ms as he died, over the threshold of the bed- om."

"A little child shall lead them." Good- ess knows, little Susan did her best. At e frail age of 9, the eldest of the four nall children, she realized her respon- sibility — the watchfulness of motherhood bred in her at that early age. She did her best, but no fire escape would have done little Susan or her family any good! No fire drill would have done little Susan or her family any good! They died, all of them, without even a fighting chance.

Let's look still further into the Gregg family. The father was 37. The mother was 35, in the prime of life, well educated. Mr. Gregg was a graduate of Harvard University and Harvard Business School, lived in an urban neighborhood and could have had anything he wanted. They were careful, and conservative people.

It is positively unthinkable that either the father or the mother could ever have thought there was even the remotest possibility that such a thing could happen. They simply couldn't have conceived it! Surely if they had, they just wouldn't have gone to bed that night. If there was no other way to avoid it, they would not have been in the house!

Edward F. Powers—The New Era

The family across the street gave the alarm for this fire which killed by smoke suffocation the two occupants, one found in the kitchen, the other in a bedroom. The photo was taken by a volunteer fireman on arrival at the scene in Westbrook, Conn. The fire occurred Oct. 4, 1950.

This is not an isolated case. It happens to be one that had a particular interest to me, one that happened near my own home. Let me read you another one:

"Chicago, April 25. Robert M. Roloson, 39, director of United Air Lines, his wife and two of their three small children, perished early today in a fire that raged through their 23-room mansion in the exclusive Woodley suburbs. The only survivor of the family was Robert, 9, and he was carried to safety by a maid. Captain David Woods of the Fire Department said the fire was discovered shortly after 1:00 A.M. by the maid, but the intensity of the blaze prevented the rescue of other members of the family besides Robert.

"Captain Woods said the fire, which was confined principally to the central portion of the house, might have been caused by sparks from a fireplace."

The next one I wish to read occurred on August 9. They don't all happen in the winter.

"Tuxedo Park, New York, August 9. William T. Adee, socially prominent New York City sportsman, and wife perished in a fire that destroyed their home early today. Their 21-month-old son, George T. Adee, an only child, was saved by the heroism of a young nursemaid and a volunteer fireman with a broken arm. Mr. Adee, who was 37, was one of the East's best known amateur court tennis players."

This active man undoubtedly would have jumped out of the window if he had had a chance. Other similar tragedies include the following:

"Mrs. Katherine Roome, 40 years old, active in community affairs, was suffocated after being trapped by a fire which destroyed her home at 8 Edward Court."

* * *

"Frederick C. Lane, sports makeup editor for the *Boston American* died of smoke inhalation when fire caused $5,000 damage to his home. Alone at the time, Lane was trapped in a second floor bedroom of the two-story, single family dwelling."

* * *

"Mrs. Donald Mackenzie, wife of the Assistant Telegraph Editor of the *New York Daily News*, former war correspondent with the Third Army, perished at 2:35 A.M. today when fire destroyed their two-story frame dwelling in the Rowayton section of this city. Mr. Mackenzie, suffering from shock, was taken to the Norwalk Hospital and discharged after treatment."

They go on and on. We cut them by the dozens from the papers.

"Pittsburgh, February 20. Stanton S. Hertz, 48, vice president of the Copperweld Steel Company at Glassport, Pennsylvania, and a daughter Alice, 13, died and his wife and another daughter were injured today when fire swept their Pittsburgh home. Fire Captain Wm. H. Thompson said that Mrs. Hertz, 46, and a daughter, Lois, 15, were injured when they leaped from a second floor window."

* * *

"Fayetteville, Ark., Dec. 26. Two Catholic priests were burned to death early today when fire destroyed a two-story frame rectory adjoining a church here. The priests were trapped in an upstairs apartment."

A Pattern Is Apparent

Isn't it clear that these fires follow a similar pattern, that they are all along the lines of the Gregg fire? Persons largely in the prime of life, intelligent, well educated, most of them well-to-do, capable of providing any safeguards they might desire or need, capable of doing any structural alterations to their homes which might appear to be necessary, and yet for some reason those things were not done. The precautions were neglected. The lives were lost. It must be that there is something wrong!

Let me read from a copy of the National Fire News, October, 1948. It is a publication of our organization, the NFPA. In it we find this: "Just to illustrate how *easy and painless* fire prevention really is: The U. S. residential fire loss alone could be cut 50 per cent if all American homes had these four features: Properly installed heating plants, adequately safeguarded; Properly constructed chimneys; Fire resistant roofing; Sound and adequate electric wiring."

These are certainly good precautions but the words I wish to emphasize are: "Just to illustrate how *easy and painless* fire prevention really is." I wonder if effective fire protection really is *easy and painless?*

Let me read an excerpt published in 1949 from another industry publication. "Fire safety does not necessarily involve any considerable expense, but only intelligent thought and action before the fire." How many people have you met who thought they were not intelligent? Is the world full of people who think they are not intelligent? I think not. I think nearly everyone thinks he is intelligent and feels that the care which he exercises is adequate.

Then we go to another quotation, this one published in 1950. It says, "The worst of it is that 9 out of 10 of these fires are preventable." With this statement, we certainly have no argument. It then continues, however, to conclude: "If our people can be taught to take *simple elementary precautions,* most of these wasteful fires will be eliminated."

Fire Safety Takes More Than Care

I think here is where we go astray. I believe we have failed to let the American people know that the problem of preventing fire in the home is like the problem of preventing fires in industry, in commercial establishments and elsewhere. *It is not an easy and simple thing.* It is a task of every hour, of every day, of every year. It requires eternal watchfulness, to check each and every possibility of failure, to eliminate every possible source of potential ignition which we can get to, and then, perhaps, to do more.

What do we do in our factories and mercantile establishments? Of course we are careful. We are careful under the direction and the compulsion of the best informed fire protection engineers in all the world. But these experts require, in addition to carefulness, that the plant be protected by automatic sprinklers, auto-

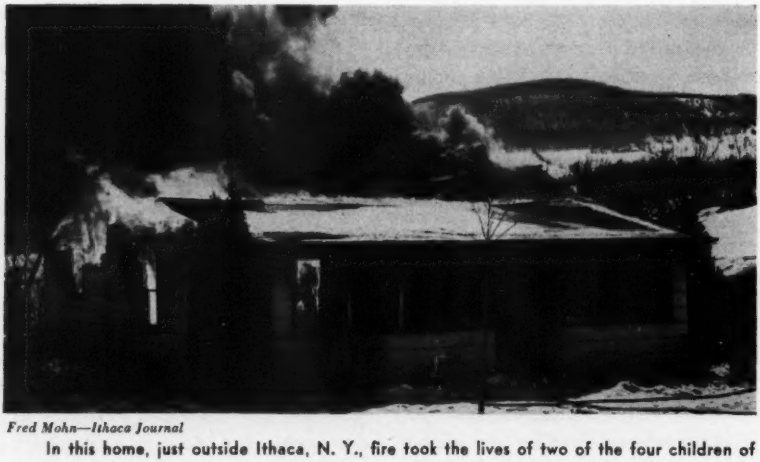
matic fire detection systems, watchmen, and other types of protective devices. Why? *Because it is known, and long and conclusively proven, that the care to be expected of ordinary human beings is insufficient to eliminate fire!* It just can't be done!

We can eliminate all smoking; we can eliminate all electricity; we can eliminate almost any other individual thing that may cause a fire and we are still going to have unforeseeable fires! We are going to have that oil burner in our home which functioned properly last night and every night before for five, ten or fifteen years; which has been carefully maintained, recently inspected and checked, and kept presumably in first class condition; yet suddenly, without warning, it goes wrong. We rarely know why. The remains just don't tell us, but fire breaks out and destroys us.

The electric wiring in our walls has been mentioned. It is not only the overloading of circuits which causes electrical fires. Loose connections and broken wires cause arcs which also start fires. "BX" cable we all know from the old days, before there was a ground wire. It has probably burned more buildings than any other electrical device, and is still doing it. Modern wiring is not always done with care. The electrician who is supposed to tie in the ground wire with the BX armor may forget it. He may not be careful and it may work loose. Who can tell? Who knows when or where fire from this cause is going to occur? If we knew, surely we would have the wiring removed.

You will notice that I have carefully specified the dates of the references I have cited, 1948, 1949 and 1950. I do not object to the conclusion that care will prevent 9 fires out of ten. But I do object to the conclusion that care will prevent *all* fires; that is any degree of care which it is reasonable to expect of human beings.

It is perfectly ridiculous to me that Mr. Gregg and his family should have lost their lives. Countless good fire detection sys-



Fred Mohn—Ithaca Journal

In this home, just outside Ithaca, N. Y., fire took the lives of two of the four children of Mr. and Mrs. George Guest. Lack of water hampered fire fighters from several rural fire companies following the delayed detection.

tems are on the market which would have given them ample warning. For a few hundred dollars Mr. Gregg could have installed one of these systems. He needed a detector to pick up the excessive heat and an alarm to awaken the sleeping family. The fire was presumed to have started from a spark from a smouldering fireplace fire which dodged the fire screen.

Recent NFPA Recommendations

I think the public is convinced that if they are careful they will not have a fire. We all think we are safe. We believe we are careful. We do the things we think are necessary, but they are not enough!

In March, 1952, the NFPA, in a book entitled "Preventing Home Fires,"* says this:

"Before fire occurs, (1) Plan to escape—" and they refer to alternate escape routes and the like. "(2) Install automatic fire detection equipment."

In other words, let's begin to treat our homes like we treat our factories, our schools and some of our hotels and prisons.

Further, the NFPA says, "Automatic fire alarm equipment to provide notification of the fire when still small is of great value in arousing occupants before fire or smoke blocks normal exits. Suitable fire alarm equipment is listed by Underwriters' Laboratories, Inc."

Also the NFPA, through its Committee on Signaling Systems and Thermostats, recognized further that care alone is not enough to eliminate the hazards of fire from the home by the preparation and publication of NFPA Standard No. 74† entitled, "Recommended Good Practices for the Installation of Automatic Fire Alarm Systems for Private Dwellings." I hope all of you who have not obtained a copy of this will obtain one and will read it carefully.

Among the things which are emphasized in this publication is the following: "It is essential that equipment be adequately reliable in operation and provide an alarm so located and sufficiently loud to awaken sleeping occupants; any equipment which is not reliable in operation or does not awaken sleeping occupants may give a false sense of security. Attention is directed to the fact that self-contained unit alarm devices located in basements or other space remote from sleeping rooms may not awaken sleeping occupants. The detectors should be of an approved type which are known to be suitable for fire-protective application. . . . Location of detectors with respect to prompt detection should be the primary consideration in any installation."

In other words, if we are going to use home fire detection equipment, let's have good equipment; let's get it properly installed; let's get the detectors in the right place.

Then it emphasizes what seemed to the Committee an important point: "Alarm bells or other sounding devices for indicating operation of a fire detector should be permanently installed and located where they will be audible to occupants of sleeping quarters under all normal conditions", including, of course, the cold winter night, when the doors are rattling and the house is shaking, and if a fire gets away, it could be most disastrous.

Maintenance and various other features are also stressed. All the equipment should

*Copies available from the Association, 25¢ each.

†Copies available from the Association, 5¢.

be tested frequently to insure operation and any defective parts replaced.

Approved Equipment Essential

I am not as well prepared as others in the field to give you figures on the amount of home fire detection business being done today. Most of it is on a strictly legitimate basis and is being reasonably well done. Unfortunately, this cannot be said of all that is being done in this field. Part of the so called "fire alarm" business is not what

Acme Newspictures

All but one member of the George Olsen family perished in this fire which destroyed their 2½-story frame home. The alarm was received at 2:03 A.M. and was turned in by a 25-year-old sailor who had just returned from service in Korea and happened to be across the street. The mother and father and three daughters, 21, 13 and 8 died.

it ought to be. I suppose the efforts of the fire protection fraternity to rectify the improper operations will be less effective than those of the public in the long run, but I hope that in the installation of fire detection systems in the home we bear in mind the importance of the proper location and proper spacing of fire detectors, the use of good and approved equipment and the observance of established and well known fire protection principles.

I hope that the insurance industry will cooperate. However, I hope that no person connected with the fire alarm industry will suggest that any rate credit be given for the installation of automatic fire detection systems in the home. I may not speak for the entire industry which I represent but it seems to me that we have something to sell which is beyond the value of all insurance. Who would say what Mr. Gregg would have given to preserve his children, his wife and himself—to preserve even one of his children?

Automatic fire detection systems, properly installed and maintained in accordance with the published standards of the NFPA can do much to eliminate the awful toll of the hidden, sneak attack of fire. I do not like that expression, "sneak attack," but if there is any situation in which a sneak attack is effective and devastating, it is fire in the home which starts during the night and is discovered too late.

Summary

In summary this is my message regarding automatic fire detection for the home.

Acme Newspictures

The 14-year-old daughter of a New York attorney perished from suffocation in this Garden City, Long Island dwelling fire, Dec. 11, 1948. The need for thermal detection equipment was cited by the fire chief, who noted that the fire had gained fatal headway before it was detected at 2:55 A.M.

No degree of care which it is reasonable to expect of ordinary human beings will protect the modern home from fire. The comforts and conveniences of American living involve countless potential sources of ignition which may break loose at any time without warning.

Nearly half of all the fire deaths in this country occur in dwellings where occupants sleeping upstairs are trapped or suffocated. These people are the victims not so much of fire as of the delayed discovery of fire.

Modern fire detecting systems installed and maintained in accordance with the published recommendations of the National Fire Protection Association can do much to eliminate delayed discovery from the hazards of fire in the home. These recommendations are based on the use of approved equipment and emphasize the proper location of both detecting elements and alarm signals.

Meetings of Board of Directors

New York, June 9, 1952

Present

A. H. S. Stead, President
T. S. Duke, Vice-President
Hovey T. Freeman, Secretary-Treasurer
Richard E. Vernor, Chairman

A. H. Baum
A. L. Brown
C. H. Bunn, Jr.
Loren S. Bush
J. E. Frederickson
Leonard Lund
R. D. MacDaniel
John Neale
W. W. Sampson
R. C. Sogge
John L. Wilds

Percy Bugbee, General Manager, Robert S. Moulton, Technical Secretary.

Business Transacted

1. The presentation of an award to the National Commission on Safety Education of the National Education Association for fire safety activities was approved. (Detailed record of presentation of this award will appear in the NFPA *Proceedings*, 1952.)

2. It was voted to discontinue the NFPA Railroad Section in accordance with the request made by the officers of the section, no objection having been registered by any NFPA member as a result of the publication in *Fire News* of the proposal to discontinue the section.

3. It was voted to approve the report of the Chairman of the Board of Directors, Mr. Richard E. Vernor, for presentation to the annual meeting as written. (This report will appear complete in the *Proceedings* of the meeting.)

4. The Treasurer's report was approved and Treasurer Freeman was authorized to present it to the annual meeting in summary form. (A reproduction of the summary form appears in *Fire News* for June 1952 and the complete report will appear in the 1952 *Proceedings*.)

5. It was voted to authorize the Committee on Hospital Operating Rooms to present a supplementary report for action by the annual meeting dealing with certain details of the methods of tests of conductivity of flooring. (Complete text of the supplementary report will be printed in the 1952 *Proceedings*.)

6. It was voted to authorize the Committee on Safety to Life to present a supplementary report for action at the annual meeting proposing additional amendments

to the Building Exits Code on the matter of protection of escalator openings. (Complete text of the supplementary report will be printed in the 1952 *Proceedings.*)

7. General Manager Bugbee reported that Mr. Thomas J. Hargrave, Chairman of the Board of Directors of Eastman Kodak Company, had agreed to accept the chairmanship of the Field Service Sponsors Committee to succeed Mr. Henry D. Sharpe, resigned.

8. It was voted to proceed with the plans for holding a regional meeting in Houston, Texas, December 1-3, 1952, and to postpone the regional meeting planned for Cleveland in the fall of 1952.

9. General Manager Bugbee reported on the developments in the farm project outlining steps thus far taken in soliciting funds. Mr. Bugbee also presented a leaflet describing the various NFPA special projects prepared by the staff for circulation to the membership. These various activities were approved in principle with authorization to the staff to continue the solicitation of funds therefor.

10. It was voted to confirm the suspension of membership service to certain NFPA members in countries within the so-called "iron curtain" pursuant to the communication on this subject received from the U. S. State Department.

11. It was voted to hold the next meeting of the Board in Boston on July 14.

12. Board member A. H. Baum whose term on the Board expires after this meeting expressed appreciation for the consideration given to the fire problems of building officials during his term on the Board and expressed gratification that he had been able to participate in this activity and the hope that the NFPA would in the future give continuing consideration to the part played by building officials in the promotion of fire protection through proper building construction.

Boston, July 14, 1952

Present

Allen L. Cobb, President
T. Seddon Duke, Vice-President
John A. Neale, Vice-President
Hovey T. Freeman, Secretary-Treasurer
Richard E. Vernor, Chairman

Warren J. Baker
Donald C. Bowersock
A. L. Brown
C. H. Bunn, Jr.
James E. Frederickson
R. D. MacDaniel
Frank D. Ross
R. C. Sogge
Henry G. Thomas

Percy Bugbee, General Manager, Robert S. Moulton, Technical Secretary, Horatio Bond, Chief Engineer, Charles S. Morgan, Assistant General Manager, George H. Tryon, III, Assistant Technical Secretary, C. I. Babcock, Engineer, Henry S. Gere, Advertising Manager, Stanley Earle, Flammable Liquids Engineer, Melvin R. Freeman. Public Relations Manager, Richard E. Stevens, Engineer, Paul R. Lyons, Associate Editor, *Firemen,* H. E. C. Rainey, Chairman Membership Committee.

Business Transacted

1. In accordance with the recommendations of the 1952 annual meeting, the following officers were elected: President, Allen L. Cobb; Vice-President, T. Seddon Duke; Vice-President, John A. Neale; Secretary-Treasurer, Hovey T. Freeman; Chairman, Board of Directors, Richard E. Vernor.

2. The Advisory Committee for 1952-53 was appointed as follows: Richard E. Vernor, Chairman, Allen L. Cobb, T. Seddon Duke, John A. Neale, Hovey T. Freeman.

3. Messrs. J. E. Frederickson and Henry G. Thomas were selected to complete the Nominating Committee for 1953.

4. Plans for the 1953 annual meeting to be held at the Palmer House, Chicago, May 11-15, reported by General Manager Bugbee, were approved. It was further

voted to authorize the Executive Office to proceed with tentative plans for holding future annual meetings as follows: Washington, D. C., May 17-21, 1954; Cincinnati, Ohio, May 16-20, 1955; Boston, June 4-8, 1956; Los Angeles, May 20-24, 1957.

5. The Program Committee for the 1953 annual meeting appointed was as follows: Richard E. Vernor, Allen L. Cobb, Percy Bugbee, with authority to Board Chairman Vernor to appoint additional members from Chicago.

6. Treasurer Hovey T. Freeman reported on the finances of the Association indicating a favorable financial picture. This report was approved. (Complete financial report will be published in the NFPA *Proceedings* 1952.)

NFPA Special Projects

7. Reports on special projects were presented as follows:

(a) Mr. Bugbee reported on the electrical field service indicating the receipt of an additional contribution from the National Electrical Contractors Association permitting the financing of this project on a more adequate basis. It was voted to instruct the NFPA office to charge to this project an allowance for overhead expense on the same basis as for other special projects.

(b) Mr. Moulton reported on the flammable liquids field service project indicating successful operation during the year 1951-52, with a favorable balance in this fund. (See complete financial report for details.) Mr. Moulton further reported that Mr. Stanley Earle, NFPA Flammable Liquids Engineer, had resigned, effective August 15, and that plans were under way for the employment of a new flammable liquids engineer. Chairman Bunn of the Flammable Liquids Field Service Committee reported general satisfaction with this activity and with Mr. Earle's services, expressing the hope that some other equally qualified employee could be secured for this position.

(c) Mr. Moulton reported as treasurer of the Society of Fire Protection Engineers indicating a favorable balance in the Society's funds. Activities of the Society were further discussed by Messrs. Baker, Cobb and Neale, all members of the Executive Committee of the Society.

(d) Mr. Bugbee reported on the Advertising Council project indicating highly successful operations to date but reporting the great need for additional contributions to extend this project and make it fully effective.

(e) Mr. Bugbee reported on developments on the proposed field service project on farm and rural fire protection which he had been promoting in accordance with previous action of the Board. It was voted to authorize Mr. Bugbee to continue along the lines indicated, but to proceed with the proposed rural fire protection contest previously suggested only as a part of the farm and rural fire protection project at such time as sufficient funds may be subscribed to implement this project.

Gases Field Service Project

8. Mr. Moulton reported on the progress in raising funds for the proposed gas field service project indicating funds now pledged or reasonably anticipated to the amount of $18,250 and outlining plans under way for raising the balance of the $25,000 budget for this project. These activities were approved as reported and Chairman Vernor was authorized to appoint a Gases Field Service Committee to have general responsibility for the administration of the project in a manner similar to that previously in effect for the electrical field service and flammable liquids field service projects. (Before adjournment Mr. Vernor announced the appointment of the following committee: Frank R. Fetherston, Chairman, H. E. Newell, H. F. Reinhard,

C. G. Segeler, and Henry G. Thomas, with additional appointments to be made later as this project develops.)

9. The Budget for 1952-53 was approved as submitted by the Finance Committee.

10. Plans for the 1952 regional meeting in Houston, Texas, December 1-3, to be conducted in accordance with the recommendations of a sponsoring committee under the chairmanship of J. E. Niland of Houston were approved as presented by Mr. Moulton. Chairman Vernor and others discussed the Association's regional meeting program indicating the value of continuing the regional meeting programs.

11. Mr. Bugbee reported on the Public Relations Committee activities and related educational and publicity activities of the NFPA office, reporting among other matters on the recent publication of a new comic book "Blast and Fire." These activities were discussed and approved.

12. A tentative proposal by President Cobb for the establishment of a new class of NFPA membership for industrial concerns was discussed and referred to the Industrial Committee for further discussion.

Distinguished Service Award

13. A further report on the proposed distinguished service award plan for giving appropriate citation to NFPA members who render distinguished service was presented by President Cobb as chairman of the previously appointed Board committee on this subject. The committee was instructed to continue its consideration of this subject, to consult with the NFPA staff, and to make a further report at the next meeting of the Board.

14. Mr. Frederickson reported on a proposed National Fire Brigades Association outlining developments in this field in the State of Ohio and plans for similar activities in other states which might form the basis of a national association under NFPA sponsorship. The discussion reflected the views that the plan had merit, but that no action could appropriately be taken by the NFPA at this time.

15 (a). It was voted to discharge the Committee on Fire Gas Research as recommended by Chairman John L. Wilds in his report to the annual meeting and referred by the annual meeting to the Board. It was further voted to express to Chairman Wilds and other members of the committee the sincere appreciation of the Board for their conscientious service in the development and supervision of this research.

(b) It was voted to authorize the Executive Office to submit to the Board for letter ballot any recommendations from the Committees on Hazardous Chemicals and Explosives, Standpipes and Outside Protection, and Transit Operations, which such committees may complete for Board action prior to the next Board meeting, all in accordance with the votes of the annual meeting in referring these matters to the Board.

ASA Activities

16 (a). Mr. Moulton reported the lack of general support in the American Standards Association of the NFPA proposal that the ASA discontinue building code activities as such and confine its attention to building standards which had been presented in accordance with the action of the Board at the January 1952 meeting. Mr. Neale reported further on the lack of progress over a period of some 15 years in which certain phases of these activities had been in operation with little or no result. It was indicated that pending completion of formal action by the ASA on the NFPA proposal no further action by the Board was necessary at this time. Informal dis-

cussion indicated the feeling that perhaps the NFPA objectives in this matter might be met in part by natural developments.

(b) It was voted to authorize the NFPA office to submit to the ASA for approval as American Standard new and revised standards adopted at the 1952 annual meeting as follows: Building Exits Code, Dust Explosions Codes, Lightning Code, but without any further NFPA action concerning the technicalities of balance of the Committee on Dust Explosion Hazards.

Technical Committee Changes

17. The report of the Committee on Technical Committee Procedure presented by Chairman A. L. Brown was approved including action on the following matters:

The committee was authorized to proceed with the change in the set-up of the Committee on Aircraft Hangars as per action at the January 1952 meeting of the Board, limiting the scope of the present committee to matters of construction and protection and appointing a new Committee on Maintenance Operations, but not proceeding further with the proposal for another new Committee on Engine Test Cells, the need for which has not been definitely demonstrated.

Plans for handling standards on Fire Tests of Building Construction and Materials were approved as reported.

The committee was authorized to proceed with the appointment of a special subcommittee for consideration of questions of policy involved in hose specification standards including personnel outside the present membership of the Committee on Technical Committee Procedure to include representation of other groups concerned, particularly the NFPA Committees on Fire Department Equipment, Fire Brigades and Watchmen, Forest, Standpipes and Outside Protection, and the laboratories concerned.

New Committee on Garages

18. The appointment of a new NFPA Committee on Garages was authorized with personnel to be selected by the Committee on Technical Committee Procedure, subject to confirmation by the Board at its next meeting, the personnel of this committee to include appropriate representation of the points of view of various other NFPA committees concerned with individual phases of this problem including Building Construction, Flammable Liquids, Gases, Electrical, Finishing Processes, Industrial Tractors and Lift Trucks, Truck Transportation, Transit Operations and City Planning and Zoning.

19. The list of committee appointments submitted with the agenda, also a supplementary list, were confirmed in accordance with the recommendations of the Committee on Technical Committee Procedure. This committee was also authorized to proceed with other pending appointments for inclusion in the committee lists in the 1952 Year Book, subject to confirmation by the Board at its next meeting. All other NFPA technical committee members were reappointed for the year 1952-1953, except those replaced, unable to serve, or removed from the lists. The Board instructed the NFPA office to write to individual committee chairmen or members who have not been active during the past year suggesting that they should accept reappointment only if in a position to serve actively during the year 1952-53.*

20. On recommendation of the Forest Committee, it was voted to revise the scope statement for this committee to read as follows:

"The Committee functions in a technical

*Complete Committee lists as revised will appear in the 1952 Year Book to be distributed to all members in October.

and educational capacity in cooperation with forest and range fire control organizations of the United States and Canada in forest, grass, brush and tundra fire control, including coordination between all fire protection agencies regardless of federal, state and provincial, county and municipal boundaries."

21. The Committee on Technical Committee Procedure for 1952-53 was appointed as follows: A. L. Brown, Chairman, Hylton R. Brown, A. L. Cobb, H. E. Newell, R. C. Sogge.

22. In the absence of official recommendations from the Electrical Correlating Committee, no action was taken on matters concerning this committee at the meeting, but the NFPA Executive Office was authorized to submit to letter ballot of the Board any matters from this committee which may require action prior to the next meeting of the Board.

23. Messrs. Bugbee and Bond reported on the NFPA staff activities concerning the national emergency with particular reference to the so-called project "East River" in which Messrs. Bugbee and Bond are participating. Mr. Bond reviewed certain essentials of fire protection in the atomic age excerpted from a paper on this subject which he had presented at a recent symposium at the Massachusetts Institute of Technology. (Mr. Bond's complete paper will be published in due course.)

Mr. Duke reported further on developments in Washington and made particular reference to the difficulty in securing pipe for fire protection installations.

24. It was voted to hold the next meeting of the Board in New York on January 22, 1953.

25. A communication was presented from Chief John Alderson, Board member whose term expired at the 1952 annual meeting, in which Chief Alderson expressed his appreciation for the privilege of having served on the Board and general approval of the efficient conduct of NFPA affairs.

26. A suggestion from Mr. Bunn concerning inter-committee correlation in the assignment to individual committees of primary jurisdiction for certain items of concern to more than one committee was referred to the Committee on Technical Committee Procedure.

27. A suggestion from President Cobb that the NFPA library should include a collection of foreign fire protection standards was referred to Mr. Bugbee for favorable consideration.

LP Gas Fires and Explosions

An NFPA Staff Study

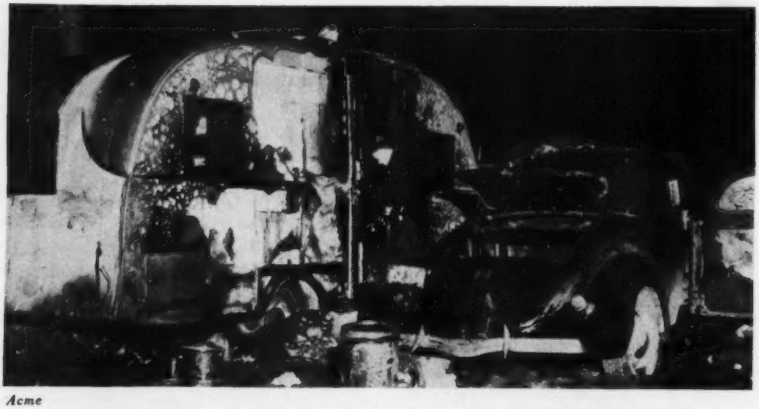
During the past 20 years many reports of fires and explosions involving LP gas have been received by the NFPA Fire Record Department. Summaries of the more serious cases and representative examples of "run-of-the-mill" incidents are presented here to make available in convenient form evidence of the types and severity of accidents that can occur if the properties of liquefied petroleum gases are not understood and if safe practices in their handling and storage are not followed. An effort has been made to present factually correct accounts but complete verification has not been possible in all instances.*

In the 129 cases reviewed herein, 165 persons were killed and 594 were injured.

LP gas, as is also true of fuel oil, kerosene, electricity and other sources of heat and power possessing inherent hazardous properties, can be used safely if recommended standards for its storage and handling are followed. Standards for the Storage and Handling of Liquefied Petroleum Gases (No. 58) were originally prepared by the NFPA Committee on Gases in 1924 and have been revised from time to time since then to keep them technically adequate, practical and up-to-date.

Pamphlet No. 58 has either been adopted in full or used in reference in most of the 48 states and is followed by virtually the entire LP gas industry. When it is realized that the estimated consumption of LP gas in 1952 will be between 4.5 and 5 billion gallons, the relatively few fires and explosions reported involving these gases is an excellent commentary on the adequacy and widespread acceptance of the NFPA LP gas standards. It is significant

*This Fire Record will be published in pamphlet form. If any inaccuracies are noted, readers are urged to advise the NFPA at once.



Acme

No. 128. East Joliet, Ill., April 4, 1947. A mother and her two children were killed by a fire caused by ignition of butane gas escaping in their trailer home. The father had brought a cylinder of butane into the trailer to be used in repair work. When he removed the valve from the cylinder butane escaped and was ignited by the gas stove or by a cigarette.

that in practically every one of the following reports where sufficient data could be obtained to determine the contributing factors, evidence was clear that some deviation from the principles set forth in Pamphlet No. 58 was primarily responsible for the fire or explosion and extent of damage.

It is also significant that in most cases the results would have been the same with natural gas, manufactured gas, gasoline vapor or any other type of combustible gas. The present study covers only cases where liquefied petroleum gas was involved, including so called bottle gas, various types of LP gas containers, piped systems and other LP gas applications.

HABITATIONAL OCCUPANCIES

APARTMENTS

No. 1. Mound City, Mo., Jan. 28, 1951: An arsonist was believed responsible for fire that originated on the wooden porch on the rear of a 3-story brick, wood-joisted building housing a bank, post office, electrical appliance shop, offices and apartments. The alarm was given by a passing motorist at 1:30 A.M. and all occupants were able to escape, but before apparatus arrived an explosion spread fire beyond control.

Two cylinders of LP gas were located on the second story back porch. It is believed that gas released from the cylinders by the heat of the fire was carried by wind into the second story where it exploded. The 3-story building was destroyed and when a wall fell on an adjoining 1-story restaurant, fire destroyed it also.

No. 2. Miami, Fla., June 13, 1951: A man was fatally burned and his wife seriously injured when an LP gas explosion wrecked their apartment. All apartments in the building had been piped for LP gas appliances but in those apartments where no appliances were installed (none was installed in the apartment were the explosion occurred), piping was left uncapped and the valve at the meter was closed.

During the evening of June 12 one of the occupants smelled gas and notified the fire department. Firemen arrived at 1:30 A.M. June 13 and proceeded to "close" all meter valves in the building. Since some of the valves were already closed, these were actually accidentally opened by this action and the gas escaped through uncapped piping into several apartments. Ignition of gas escaping into the apartment by the lighting of a kerosene lamp is one explanation of the explosion. It is also possible that gas entered the apartment from a leak in a cracked coupling at a stove of an adjoining apartment.

CABINS, TOURIST COURTS*

No. 3. Cleveland, Tenn., Jan. 25, 1947: Following the installation of an LP gas heater in one of the tourist cabins, an employee discovered the gas left on at the heater. The employee shut off the gas and opened a window. Later when he struck a match an explosion occurred that severely damaged the cabin and fatally burned another employee.

No. 4. Longmont, Colo., Jan. 21, 1948: Leaking LP gas in a tourist cabin traveled through a hole in a partition to an adjoining cabin where it was ignited by the flame from a gas heater. The ignited gas flashed back into the cabin of origin and exploded, injuring an occupant and causing severe damage to the cabin. The hole in the partition had been for gas tubing.

No. 5. near Bina, Minn., Sept. 25, 1949: One man was killed and his four companions were seriously burned when an explosion of propane partially wrecked the 1-story reinforced concrete cabin in which the men were spending the night. The gas apparently leaked from a propane stove and exploded when one of the men arose at 5:45 A.M. and lit a cigarette.

No. 6. Bemidji, Minn., Aug. 26, 1950: A trailer, made into a permanent cabin, was rented to four guests. The owner wanted to explain the stove to the guests but was advised by them that they were familiar with it. When the oven burner was turned on but not lit, gas filled the room and was ignited by the other burners of the stove. The guests were injured in the explosion.

No. 7. Keene, N. H., Oct. 5, 1950: Two guests were fatally burned in an explosion and flash fire that occurred when one of the guests struck

*See also Case No. 98.

a match to light the LP gas heater. It is believed that a free turning valve on the gas heater had not previously been shut-off completely and gas had accumulated near the floor of the cabin.

No. 8. East Lyme, Conn., Jan. 11, 1951: Propane from a gas heater escaped, through malfunction of the heater, into the cabin and was ignited when a guest lit a cigarette. The resulting explosion and fire destroyed the cabin and severely burned the guest.

No. 9. Pendleton, Ore., May 30, 1951: Ignition of LP gas escaping from a partially open valve on a space heater was the cause of an explosion that resulted in the death of the only occupant and minor damage to the 20 ft. sq. 1-story stuccoclad cabin. Fuel to operate the space heater was supplied through a distribution pipe that ran along the outside of the rear wall of six adjoining cabins. Each cabin had an individual take-off from the distribution pipe, controlled by a shut-off valve. An additional shut-off valve was located in the line leading into the space heater. The heating unit in cabin No. 3, where the explosion occurred, was provided with a manually operated valve but had no pilot light or thermal shut-off.

The victim, who died of second and third degree burns several hours after the explosion, stated that the explosion occurred when he awakened in the morning and lit a cigarette. Investigation revealed that the valve on the stove was partially open and that all piping was gas-tight.

DORMITORY

No. 10. Seguin, Texas, Feb. 9, 1936: Butane gas leaking from a kitchen stove that had been giving trouble ignited at live coals in a kitchen heater in the unsprinklered 4-story brick, wood-joisted college dormitory. Smoke from the fire awakened occupants on the third and fourth floors at 4:00 A.M. in time to escape. However, due to lack of fire protection for the building located outside the city limits the building was completely destroyed.

DWELLINGS

No. 11. Las Vegas, Nev., 1932: A lighted match resulted in an explosion of liquefied petroleum gas in the basement. Later developments proved that the service line had not been properly tested after installation. At the point where it had been bent to make connection with the meter, the pipe had split, causing gas leakage that filled the basement with an explosive mixture.

No. 12. Duxbury, Mass., May 8, 1934: One cylinder of a butane-propane gas system, which had been installed in the cottage for hot water purposes, had become exhausted. The hired man turned off the supply at the heater, changed over to a new cylinder, and went immediately to the cellar to light the burner under the heater. A leak in the connecting pipe had saturated the cellar with gas and as the man struck a match an explosion took place which burned him severely. The explosion blew the outside door to pieces and blew up part of the floor of the first story kitchen. A small fire was quickly extinguished.

No. 13. DeRidder, La., Nov., 1944: Explosion and fire that caused the death of four persons and destruction of the farmhouse occurred when one of the four looked for a leak in a liquefied petroleum tank with a match. Although details are not available, it is probable the tank was located inside the building.

No. 14. Nr. Tulsa, Okla., Aug. 26, 1945: Three prospective tenants of this unoccupied 2-story dwelling were killed when leaking butane gas exploded. The explosion is believed to have occurred when one of the victims lit a match. Paper on walls, window shades, and doors were burned and paint was blistered by the explosion but fire did not persist due to the absence of combustible furnishings.

No. 15. Salem, Ill., Oct. 12, 1946: A dwelling was demolished and three persons injured in an explosion of propane gas that occurred after a tank truck delivered propane to the storage tank located 50 ft. from the house. At the time of the explosion a pipe was being installed from the dwelling to the tank. The tank had not been connected.

No. 16. Platteville, Wisc., June 20, 1949: In order to remove a water plug in the service line from the street main, a vacuum pump with a non-explosionproof motor was connected to the service line in the basement of the dwelling. In using this device the water with some gas was pumped into a waterproof but not gas-tight bag on the equipment. Workmen had completed removal of water from the line and were preparing to use the vacuum pump to free the basement of gas when an explosion of such force

occurred that it raised the house from its foundation and demolished it. One of the two servicemen was severely burned. A spark from the pump motor was a probable ignition source of the liquefied petroleum gas that had accumulated in the basement.

No. 17. Alpharetta, Ga., Aug. 19, 1949: Approximately 350 gallons of liquefied petroleum gas had been transferred to a recently installed underground 500-gallon tank when an explosion occurred injuring five persons and causing extensive damage to the dwelling. The tank had not as yet been connected to house piping but since the tank truck was in the neighborhood it was decided to fill the tank. The explosion was centered about 12 feet from the tank in a pit under the house where a water tank and pump were located. Although the source of the leaking gas is unknown it may have been from a leaking valve at the tank. There is also the possibility that the tank was bled while being filled.

No. 18. Estelline, S. D., June 25, 1950: A 100-gallon tank and appliances had been installed but since no tank truck was available there was a delay in placing the system in operation. About noon the occupant obtained a cylinder of liquefied petroleum gas from the dealer, returned home and installed it without a regulator. The stove worked satisfactorily; an LP gas refrigerator and hot water heater were not lit. When the fuel truck arrived at 5 o'clock the driver filled the tank, removed the cylinder, and went into the basement to light the hot water heater. At this moment an explosion occurred severely burning the driver and causing fire that damaged the home. On investigation it was found that the gas escaped into the basement from a ruptured copper tube.

No. 19. Near Helotes, Tex., Aug. 15, 1950: The owner of this ranch decided to relocate the kitchen stove, and to get butane gas to the new location he used piping concealed under the kitchen floor that had not been used for several years. Unknown to the owner the piping leaked. On the following day, when he went to the cellar and operated the light switch, an explosion occurred that caused fatal injuries to him and major structural damage to the building.

No. 20. Greenwood, Nebr., Sept. 9, 1951: Returning home after a week's trip a man and his wife on entering their four-room house smelled LP gas. The husband turned on the small air conditioning unit in the living room and then decided to open the kitchen door to assist ventilation. Just as he took hold of the knob an explosion occurred that blew him and his wife into the yard and wrecked the house. A report of investigation by the State Fire Marshal's office expressed the opinion that the leak came from a range pilot light or burner, and that the accumulated gas was ignited by a refrigerator unit after the gas concentration had been reduced to within the explosive range by the air conditioning unit.

HOSPITAL

No. 21. Hammond, La., Jan. 21, 1940: A tank truck had arrived to fill a 150-gallon butane supply tank which was buried behind the hospital in an open area. The heaters had been inoperative for three days, making it necessary to drain the system. As the union at the nearest heater was disconnected, liquid butane squirted as high as the ceiling, its vapors being ignited by two open grate fires in the vicinity. Three persons were injured and, due to lack of water for fire fighting, the building was destroyed. It is possible that the unusually low temperature (10 degrees) at the time of the explosion caused liquefaction of the butane gas on the low pressure side of the regulator toward the top of the tank. Total loss: $3,000.

HOTELS*

No. 22. Saratoga Springs, N. Y., Sept. 5, 1930: On hearing strange noises in the refrigerator, the cook at this sprinklered 3-story wooden hotel called the hotel owner to investigate. When the refrigerator door was opened a series of small explosions occurred and the resulting fire so severely burned the owner that he died eleven weeks later. The fire department extinguished the small blaze in the refrigerator with a 2½-gallon soda-acid extinguisher. The force of the explosion blew out the kitchen skylight but did not damage sprinkler piping. There were no sprinklers in the refrigerator.

The cause of the explosions was ignition of gas leaking from piping of a refrigeration unit that used isobutane as its cooling medium. The gas is believed to have ignited at a gas stove.

No. 23. Benton Harbor, Mich., July 24, 1940: While an underground 500-gallon butane storage tank was being filled from a small tank truck, a slight explosion occurred followed by

*See also Case 114.

the violent explosion of the storage tank. The explosions and ensuing fire killed three people, seriously injured six and destroyed the hotel dining hall and two near-by buildings. Since the truck driver was killed it was impossible to determine with certainty what happened. It is known that the driver was aware of danger since he shouted to people to leave the building just before the explosions. The fact that the second explosion almost completely uncovered the tank (buried two feet below the ground) and tore one end from the tank suggests that the tank was subjected to abnormally high internal pressure. This pressure was probably due either to abnormally high vapor pressure of the butane that had been subjected to 95° F. atmospheric temperature in the truck, or to excessive hydrostatic pressure if the tank was liquid full.

No. 24. Woodridge, N. Y., July 20, 1949: On a very hot day while a 600-gallon tank was being filled from a tank truck the relief valve on the truck began to "pop off." Escaping gas ignited at an open flame hot water heater 65 feet away. Fire flashed to the tank truck destroying the truck and a near-by one-story wooden building used as a kitchen for the hotel.

MERCANTILE OCCUPANCIES

BEAUTY SHOP

No. 25. Harrisonburg, Va., July 30, 1947: A spark from a beauty machine, or a smoker's lighted match, may have been the source of ignition in an explosion of an accumulation of butane gas (tank located in the basement) which killed 10 women and injured 25 customers of a beauty shop. Other employees and street walkers were also injured when struck by flying glass and pieces of brick.

DEPARTMENT STORES

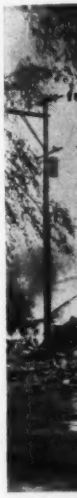
No. 26. Lumberton, Miss., Oct. 5, 1942: One person was killed, several injured and five adjoining 1-story brick and wood buildings were destroyed following explosion of an accumulation of liquefied petroleum gas in the 2,560 sq. ft. basement of the brick, wood-joisted department store. On Sunday, the day preceding the explosion, the owner of the store detected gas in the basement. On Monday morning while he was in the basement with a gas company employee attempting to locate the leak a violent explosion occurred burying them under wreckage. Thirty minutes later after firemen had rescued both men and were preparing to return to quarters a second explosion occurred which was followed by fire that destroyed five adjoining buildings.

Investigation revealed that the gas supply had not been shut off at the underground storage tank 15 ft. from the store before the gas company employee entered the basement nor was it shut off after the first explosion. It is possible that the first explosion would not have occurred and almost certain that the second explosion would not have taken place had this precaution been taken.

No. 27. Winchester, Va., June 23, 1948: At 9:55 A.M. an explosion occurred in a department store which killed one person and injured 18. The explosion was caused by the ignition of an accumulation of propane gas in the basement when an employee struck a match. Employees and early morning shoppers were trapped in the debris which resulted from the blast. Very little fire ensued. The propane service to the building was from a gas line in the street, and from information available to the NFPA it would appear that the street main was the source of the leak. Exactly how the gas entered the store basement is not explained.

FURNITURE STORE

No. 28. Stevens Point, Wis., June 11, 1951: Propane gas leaking from a ruptured 3-inch cast iron main in the street is believed to have entered the basement of a 1-story concrete block, wood-joisted furniture store through holes and cracks in the basement wall. The building was located about 15 ft. from the main which had ruptured. When a light switch was operated an explosion occurred that killed one occupant and injured two. The roof was raised and the walls fell out, allowing the roof to fall back into the building. Debris was thrown several hundred yards and within one or two minutes the wreckage was in flames. Extending roof eaves and unprotected windows afforded ready means fo flames to reach an adjacent 1-story masonry wood-joisted club building. The building and



Stevens Pt., Wisc., June 11, 1951. One person was killed when a gas explosion wrecked this furniture store. (See Case No. 28.)

three 2-story wooden buildings across a 50 ft. street, ignited by radiated heat, were destroyed. Loss was estimated at $208,500.

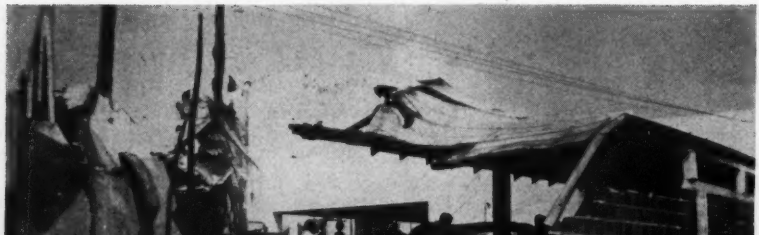
GAS APPLIANCE STORES

No. 29. Austin, Texas, April 5, 1937: An explosion of butane in this store slightly burned two men, blew down a fibreboard partition and blew out three plate glass windows. Investigation revealed that the explosion occurred just as a truck driver completed transfer of 50 gallons of butane into a 190-gallon steel tank used as a supply source for demonstration appliances. The butane that exploded escaped from a leaky filling hose. Contrary to NFPA recommendations (Pamphlet No. 58, par. B.5) that the tank be not less than ten feet from the building, this particular tank was located on the floor in the building.

No. 30. Welasco, Texas, Mar. 12, 1940: An inexperienced service man was handling a 25-gallon cylinder of butane in a salesroom where gas appliances were on display. Through accident, mistake, or ignorance the man unscrewed the cylinder valve assembly just enough to allow the pressure to blow it off and allow the gas to escape into the room. An open pilot flame on one of the demonstration ranges ignited the gas and an explosion and fire followed. Three school girls passing the building were seriously injured, one fatally, and two employees of a garage occupying a part of the 1-story brick, wood-joisted building were injured. The explosion blew out one wall and enough of two others to allow the roof to collapse. Plate glass store fronts and windows in dwellings were broken for a distance of one to three blocks. Property damage was reported as being $25,000.

Robert Kerr

Welasco, Texas, March 12, 1940. Explosion of butane accidentally released from a cylinder wrecked this gas appliance store. A schoolgirl passing by was fatally injured. (See Case No. 30.)



George West, Texas, July 5, 1938. Four persons were killed and 20 injured by an explosion and fire resulting from careless transfer of butane from a tank truck to an underground tank at this restaurant. (See Case No. 32.)

GROCERY STORE

No. 31. Mission Twp., Kans., Nov. 23, 1950: The contents of a large area 1-story mostly fire-resistive grocery store were destroyed by fire that was coming from the front door when discovered at 9:40 P.M. During the fire, one of the valves of a ceiling unit heater burned off, allowing full discharge of propane from the heater, which increased the intensity of the fire until the gas was finally shut off by firemen at the 1,000-gallon storage tank located 200 ft. from the building. Despite the severity of the fire the walls and roof of the building were found to be structurally sound after extinguishment. Loss was approximately $130,000, including smoke and water damage to exposures.

RESTAURANTS

No. 32. George West, Texas, July 5, 1938: Four persons were killed and twenty injured by an explosion and fire resulting from careless transfer of liquid butane from a tank truck to an underground tank. The storage tank supplying fuel for a small restaurant was buried two feet under the concrete floor of a small storage room adjacent to the kitchen of the restaurant, and was equipped with two inlets, one to take the gravity flow of the LP gas from the tank truck, and the other to allow for an equalizing pressure hose returning to the tank truck. In this case the driver of the truck merely uncapped the equalizing pressure inlet and allowed the pressure and vapors to vent into the storeroom, this despite the objections of the cook. The driver busied himself elsewhere and allowed the tank to fill without supervision. The tank was overflowing from the open pipe when he returned. He rushed to the gages which told the situation and then hurried to the discharge valve on the truck and started to close it. Meanwhile the gas reached the burners in the kitchen, causing a violent explosion which burned the driver severely and caused him to leave before the flow had been completely shut off.

Not only was the restaurant demolished, but a house 50 feet away had evidently been filled with the escaping gas, and also exploded. The negligent truck driver, a dishwasher in the restaurant and a woman and her daughter, customers in the restaurant, died. The cook who was not so indifferent to safety measures as the truck driver escaped with injuries since he had started his escape by means of the nearest window as soon as the overflow was noticed.

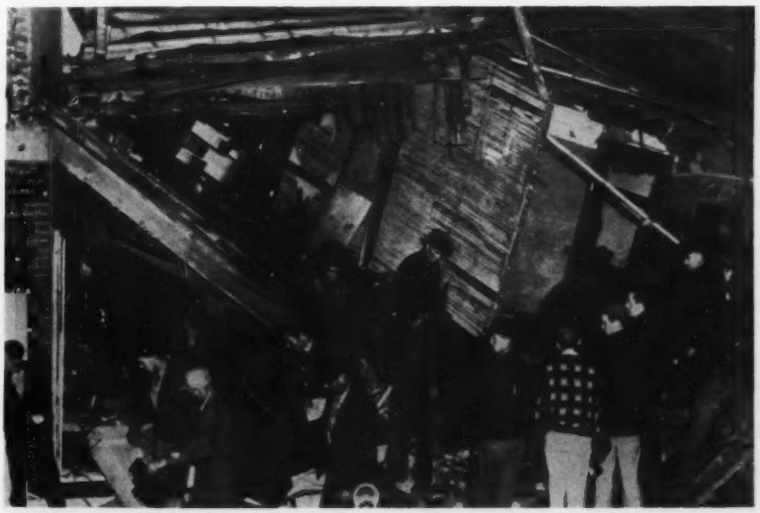
Examination of the equipment after the fire showed the underground tank to be of substandard design without safety devices. One end of the tank was found to have come up out of the ground and the head at that end had been blown off. It was supposed that this had been done by the pressure in the tank truck which had continued to be applied after the tank was filled. The truck was of standard design and was not a contributing factor in the accident.

The heat of the fire opened pressure release valves and gas burned as it escaped.

No. 33. DeGraff, Ohio, Jan. 30, 1939: A 500-gallon underground tank was being filled from butane cylinders carried on a service truck. During the operation a terrific explosion occurred, killing two men, injuring another, and doing extensive property damage. Examination revealed that the weld at one end of the tank had practically disappeared, leaving an opening about four inches in length through which gas had escaped. The cause of ignition was apparently a coal stove in the restaurant not far from the tank. Though the tank had passed factory inspection four years earlier, hard service had resulted in a deterioration of the joint from which the gas escaped.

No. 34. Brewster, N. Y., June 13, 1939: A fatal liquefied petroleum gas explosion occurred while LP gas company employees were installing service in a second floor apartment of a 3-story brick, wood-joisted building. While a tank of gas was being placed in position outside the building one of the employees stumbled, causing the tank to fall and a valve to snap off. The workmen warned three spectators to flee and ran to surrounding buildings to put out all fires. Unfortunately the spectators stayed to watch. The kitchen employee in a restaurant across a 4-ft. alley did not have time to shut off all burners before gas entered the 2-story wooden restaurant building and exploded. The spectators were killed and the restaurant in which the blast was centered was destroyed. The gas tank was not an I.C.C. cylinder and had no protection against accidental damage to the valve.

No. 35. Onset, Mass., July 18, 1946: A plumber who was called to repair a butane gas leak in a restaurant located in the center of the business district accidentally broke the high pressure line from the street main near the meter. The gas company was called by the plumber at 12:35 P.M., and the Onset Fire Department roped off the area. At 1:00 P.M. an explosion shattered four wooden buildings, killed nine persons and injured scores of others. An electric motor was the suspected ignition source. The utility employee was criticized in the inquest report as having been very slow in responding to the emergency call, although he had arrived approximately ten minutes before the explosion occurred. Property damage was $150,000.



Press Association

Nampa, Idaho, Nov. 15, 1947. Six persons were killed and more than 35 were injured when a propane explosion wrecked this restaurant. This disaster is an example of the tragic results that may occur when the provisions of the NFPA Standards for Storage and Handling of Liquefied Petroleum Gases are not followed. (See Case No. 37.)

Statesboro, Ga., Mar. 18, 1950. The explosion that wrecked two adjoining mercantile buildings occurred when a furniture store employee attempted to light a heater. Gas odors had been noted in the furniture store for two days prior to the explosion but no leaks could be found. (See Case No. 41.)

Acme

Mattoon, Ill., January 27, 1952. LP gas escaping from a buried 500-gal. tank through an unplugged ¾-inch opening is shown burning at ground level above the tank. (See Case No. 43; see also April 1952 *Quarterly*, page 360.)

No. 36. near Shreveport, La., Aug. 7, 1946: The driver of a tank truck containing 800 gallons of butane ascertained from the gauge on the 150-gallon underground storage tank that there were 30 gallons in the tank, and started to fill it. Either the gauge was faulty or had been misread since gas escaped from the safety valve shortly after the filling operation began. The driver yelled a warning to the two occupants of the restaurant, then ran about 35 ft. from the tank when a violent explosion occurred that seriously burned the driver and the restaurant occupants and caused fire that destroyed the restaurant, two smaller buildings and the truck. The underground tank was located 7½ feet from the restaurant (NFPA Standards specify a minimum distance of 10 feet for this size tank), an adjacent window was open and the pilot light on the restaurant stove was lit.

No. 37. Nampa, Idaho, Nov. 15, 1947: Six persons were killed and more than thirty-five others were injured when an explosion occurred while a truck was delivering propane gas into a 155-gallon storage tank at a restaurant. According to the chief of the fire department the truck and storage tank appeared to be unaffected by the explosion which wrecked the building. The explosion is believed to have involved gas leaking into the basement from the connection between the delivery hose and tank since one of the first rescue men at the scene stopped further flow of gas by tightening the connection. Fortunately, no fire followed the explosion but the fire department worked for several hours removing the victims from the wreckage. The explosion is another instance of disastrous results that may occur where provisions of NFPA Standards for Liquefied Petroleum Gases have been overlooked. In this instance the storage tank was in a pit immediately adjacent to the basement wall of the restaurant and beside a window leading into the basement. According to NFPA Standards the tank should have been at least 10 ft. from this building. Loss was $90,000.

No. 38. Newmarket, N. H., Jan. 16, 1948: At 4:55 A.M. as the restaurant cook lit the propane-fired coffee urn an explosion blew out the windows of the first floor restaurant and was followed immediately by fire that destroyed the 4-story wooden building housing apartments on upper floors. Despite first and second degree burns, the cook saw that all persons got out of the building. The complete destruction left no clues as to the cause of the gas leak. The owner stated that no rubber hose connections were used.

No. 39. Marianna, Fla., Feb. 6, 1952: The Fire Chief reports that a fire which caused $39,000 damage to a restaurant, barber shop, and jewelry store originated at a butane gas hot water heater in the restaurant. The 4:30 A.M. alarm was given by an occupant. An open cockloft and lack of fire walls handicapped fire fighting.

MISCELLANEOUS MERCANTILES

No. 40. Tama, Iowa, June 6, 1936: LP gas, escaping from an improperly installed compressed gas system, was ignited. The resulting explosion killed three persons and injured twenty-two others, while destroying four buildings.

No. 41. Statesboro, Ga., Mar. 18, 1950: Two employees were seriously injured by an explosion in a two-story brick, wood-joisted mercantile building. The explosion wrecked the building of origin and one adjoining building. The ensuing fire completed destruction of a furniture store, a feed store, a barber shop and a pool room. Exposures suffered moderate explosion and fire damages.

The blast resulted when an employee attempted to light a radiant space heater which was served by liquefied petroleum gas from an underground gas pipe. (The gas company serves 50 customers with gas from three 1,000-gallon underground tanks.) Gas odors had been noted in the furniture store for two days before the explosion, but no leaks could be found by the gas company employee who was called. Whether the explosion was the result of undetected leaks in the piping or gas escaping from a control valve accidentally left open on the space heater could not be determined. The loss was estimated at $300,000.

No. 42. Nashville, Ill., Jan. 5, 1952: A 1,000-gal. cylindrical LP gas storage tank located 40 ft. from the rear of a row of mostly 1-story buildings was supported at each end by two hollow concrete blocks resting on the ground. Due to intermittent freezing and thawing of the ground the substandard foundation of concrete blocks had gradually settled. To prevent further settling, men were engaged in raising the tank in order to build a solid foundation, when a capped galvanized iron pipe extending from the

bottom of the tank was snapped, releasing the approximately 50 gallons of propane in the tank. Men were sent to warn all occupants of the near-by buildings to get out at once as a blanket of vapor about knee deep followed the sloping ground toward the buildings. Apparently all were not warned, however, as several were seriously injured 15 minutes later when two explosions occurred in the row of mercantile buildings. Two buildings were severely damaged, several others received minor damage, and plate glass windows across the street were broken. Total property damage was estimated at $30,000.

No. 43. Mattoon, Ill., Jan. 27, 1952: A series of fires and explosions caused by ignition of LP gas that had leaked from a buried 500-gal. tank caused damage of varying degree to 18 buildings in a two-block mercantile area. Loss was approximately $250,000.

At 1:00 P.M., January 27, fire was seen coming from the ground above the tank which had recently been installed ten feet from the rear of a drug store. The tank had received its first delivery of 420 gals. of LP gas on January 24. The backs of several buildings within two blocks of the fire and all backing up to the same alley burst into flames a few minutes later and explosions occurred in others. Because of the fortunate time of occurrence, a Sunday, the stores were closed and there were no fatalities.

When the storage tank was dug up later a ¾-inch threaded opening not equipped with a plug was found in the bottom of the tank through which LP gas had undoubtedly escaped into the surrounding earth. Gas is believed to have entered a storm sewer, telephone conduit tunnel and an abandoned central steam heating tunnel extending through the alley and to have spread by means of these ducts to the various buildings along the alley. (For detailed report see the April 1952 QUARTERLY, page 360.)

MANUFACTURING OCCUPANCIES

ABRASIVES MFG.

No. 44. St. Paul, Minn., Feb. 8, 1951: A violent explosion of butane vapors in the basement of the 6-story fire-resistive building brought death to fourteen employees and seriously damaged the structure. The explosion occurred while liquefied petroleum gas (stated to be 70 per cent propane and 30 per cent butane instead of the usual 100 per cent butane) was being transferred from a tank truck to a 14,000-gallon storage tank 80 ft. from the building. Normally, butane was received by tank car but because of a railroad strike, truck transportation was used which required a temporary unloading connection on the storage tank. The connection was made to a low pressure air line which was connected to the building air system and ran underground from the basement of the building to the tank. (During very cold weather air pressure was needed to transfer liquid butane to the vaporizer.)

Shortly after unloading began and several minutes prior to the explosion an employee reported a serious gas leak in the basement. Before maintenance men could get to the building, however, the explosion occurred. All employees on the lower floors were killed and the first and second stories were destroyed.

A study of the arrangement of the temporary fuel connection on the air supply line at the storage tank revealed that it was possible during the unloading operation for liquid to flow back through the air supply line to the building where an open drain valve on a water condensate leg in the air line would allow gas to enter the basement. It has been concluded that the gas entered the building in this manner.

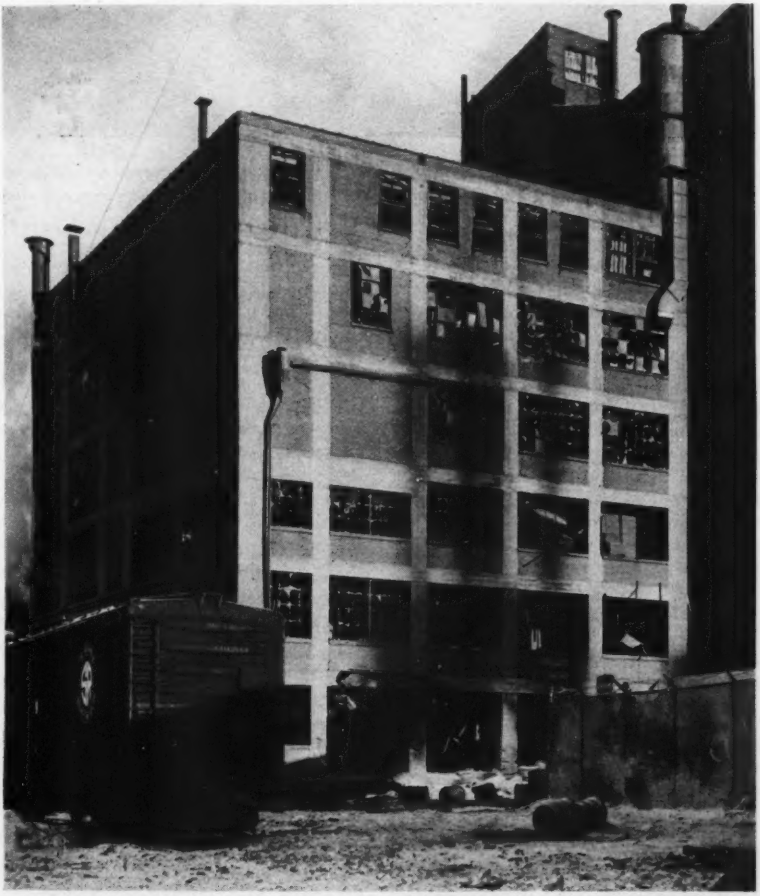
CHEMICAL WORKS

No. 45. Dayton, Ohio, Nov. 7, 1934: Butane, pentane and other similar hydrocarbons were being cracked in a tube furnace at high temperatures to obtain raw materials to be used in experimental processes. One of the two safety plugs in a cylinder of butane blew out, either through some defect or a mechanical injury. The gas escaped and was ignited by the furnace. Sprinklers, foam, soda-acid, and carbon tetrachloride extinguishers, together with a small hose stream, kept the other cylinders cool and checked the fire before the public fire department arrived. Estimated loss: $150.

No. 46. Newark, N. J., Jan. 2, 1939: A violent explosion of butane vapors in a courtyard between three buildings badly burned two employees, blew in one large metal sash in each

building, broke a fire escape door and blew down a large overhead door. The butane collected in the courtyard during bleeding of condensate from a butane system. In order to make a steam connection in the black ash department which was on the same steam header as the butane vaporizer, the butane system had been shut down until the steam connection was completed. During the shutdown condensate collected in the butane system which was removed by bleeding under pressure through a trap into the open court. The gas in the courtyard was not dispelled by air circulation and apparently some of it filtered through a pipe duct into the black ash department where it ignited. Loss was $300.

No. 47. Los Angeles, Calif., Apr. 25, 1945: When the nipple at a condenser failed, butane flowed along the floor of the butane section of



St. Paul, Minn., Feb. 8, 1951. An explosion of LP gas vapors in the basement of this abrasives manufacturing plant brought death to 14 employees and caused direct and indirect losses totaling $2,180,000. The outstanding lesson is the danger of connecting a shop air system to an LP gas system in such a way that gas can enter the building. (See Case No. 44; see also report in April 1951 *Quarterly*, page 305.)

Oregon State Fire Marshal

Warrenton, Ore., July 22, 1950. During this cannery fire a butane storage tank adjacent to one of the buildings was exposed by intense heat. However, pressure relief valves operated properly and the tank did not rupture. (See Case No. 51.)

the plant. The fire department was summoned and an attempt was made to shut off the flow before ignition, but the vapors spread to another building 150 ft. away and ignited at a boiler. The resultant explosion shattered the butane building and damaged piping, instruments and a 150-barrel butane accumulator. Adjoining pipe lines were blocked off and the butane was allowed to burn until consumed, after which the accumulator was purged. In the meantime the fire department with the assistance of two private fire brigades brought the building fires under control using hose streams and water spray. Loss was estimated at $100,000.

FOOD PROCESSING

No. 48. Barrington, Ill., Sept. 21, 1932: A serious loss involving liquefied petroleum gas occurred in this sprinklered 5-story fire-resistive tea processing plant when gas leaking from a cylinder in the basement exploded. Serious injuries occurred to three employees, minor injuries to several others and the building suffered extensive damage.

Four I.C.C. steel cylinders, each containing 150 lbs. of a mixture of propane and butane (120 lbs. pressure at 70°F.) had been brought into the basement two hours prior to the explosion and left on a hand truck near one of the freight elevators. Two or three minutes prior to the explosion an employee at work in an office near the cylinders on hearing a hissing sound discovered that one of the cylinders was leaking. (An ice and frost deposit indicated that the leak occurred at the valve.) Employees had succeeded in carrying the leaking cylinder from the building and were returning for another when the explosion occurred. The seat of the explosion was in the vicinity of the area where the cylinder was located prior to its removal. Although the ignition source is unknown, electrical sparks from a light switch, electric motors, elevator machinery or the ventilating equipment in the basement were possible ignition sources.

Despite broken sprinkler piping and failure of the fire pump to start automatically due to damaged electric wiring, eight sprinklers operated in two areas where small fires broke out and, with the help of first aid equipment, the fires were extinguished with minor damage. Total property damage exceeded $25,000.

No. 49. Los Angeles, Calif., Dec. 7, 1943: While a tank truck was discharging butane into a buried tank in the yard of a bakery, butane vapors exploded with such violence that the truck driver was hurled a considerable distance and later died of his injuries. All windows of the bakery were shattered and fire entered and destroyed the building. Windows and the roof of an adjacent building were damaged but employees using three 2½-inch hose lines extinguished the ensuing fire with minor damage.

Earlier in the day the plant engineer had subjected the heat exchanger in the underground tank to 175-185 lbs. air pressure in an attempt to force out an obstruction. Apparently the tank had been weakened by this procedure and ruptured when 1,000 gallons of butane were added.

No. 50. New Richmond, Wisc., June 10, 1946: Fire believed to have resulted from a lightning bolt striking the third floor of a one-, two- and three-story frame, ironclad cereal manufacturing plant, destroyed the main offices, print shop, packaging room, "gun room," stored grain and a farm implement warehouse section before it could be extinguished. The plant was heated by butane gas and the cereal heating retorts and lead melting pot were also operated by this gas which was supplied from an 18,000-gallon liquid butane tank located aboveground, 60 ft distant from the plant. It is considered probable that either the shock or resultant fire ruptured the 1½-inch butane gas pipe line to the gun room, but, at any rate, the escape of the gas created an intense fire. The gas supply could not be cut off for about 35 minutes after the flames were first discovered by the watchman at 12:20 A.M. because of the intense heat and flames. Loss was $212,000.

No. 51. Warrenton, Ore., July 22, 1950: Fire, that originated in the vicinity of three trucks parked in the 1-story combustible scrap reduction building at a cannery, was beyond control when discovered by an outsider. A stiff wind carried flames into the cannery and cold storage building before being controlled. During the fire a butane storage tank adjacent to the cannery was seriously exposed causing the pressure relief valve to operate several times. However, the tank remained undamaged and still contained butane after the fire.

No. 52. Woodbury, Ga., Oct. 7, 1950: The six aboveground 1,000-gallon liquefied petroleum gas tanks at this plant were about to be refilled from two tank trucks when the fitting from the number one tank to the vaporizer broke at the tank allowing gas to escape. Cause of the break is unknown. The tank cradle may have settled throwing the weight of the tank on the pipe and fitting. When the break occurred the truck driver warned employees in the building to shut off burners and leave. A few moments later an explosion occurred at the storage tank. No explosion or fire damage occurred to the plant. However, 10 tons of pimentoes were spoiled when the roasters were turned off. Since the excess flow valve at the withdrawal opening of the storage tank did not function, fire continued to burn at the break until the contents were consumed.

No. 53. Berwick, Pa., May 22, 1951: On May 21, several minor explosions occurred in the firing chamber of the oil-fired boiler equipped with a propane preheater. The explosions were believed due to failure of the automatic valve to operate properly to shut off the feed from an "empty" 100 lb. propane cylinder and open the feed from a full cylinder. On the following day a mechanic, preliminary to making repairs, shut off the propane pilot light and the preheater feed. After the timing devices had gone through their cycle the main oil burner came on and exploded unburned propane in the firing chamber. The brick firing chamber and parts of two 8-in. brick building walls of the boiler house at the potato chip factory were blown out. Loss $6,000.

METALWORKING PLANTS

No. 54. Harvey, Ill., June 2, 1932: An explosion of butane gas that had accumulated in one of five adjacent gas-fired ovens at this machine shop wrecked the walls and roof of one of the ovens when an operator was lighting the burner. The ovens were constructed of brick walls and roofs and had large asbestos-filled doors at each end. The doors had been kept closed while the ovens were not in use allowing gas from leaking piping to accumulate in the oven.

No. 55. Detroit, Mich., Dec. 17, 1932: Butane spilled in the driveway outside the automobile factory was ignited by a spark from an electric truck. The ensuing fire broke 200 lights of plain glass but plant and city firemen using soda-acid and foam extinguishers and a hose stream prevented fire from entering the building and completed extinguishment in 20 minutes. The spilled butane came from a temporary 2-inch discharge line which had been laid across the drive from a 22,000-gallon aboveground storage tank to supply plant buildings while the underground discharge line was out of commission due to a leak. The leak in the underground pipe was probably due to the corrosive action of cinder fill in which the pipe was laid.

No. 56. Newburg, N. J., July 2, 1934: Steam heat was being used to hasten the transfer of

liquefied petroleum gas from a large to a small container. The containers were brought too near a boiler room and escaping gas was ignited by the boiler fire. The small blaze that followed was put out with a hand extinguisher. No claim was made for the small damage to the insulated wire factory.

No. 57. Detroit, Mich., May 2, 1938: A butane gas-fired recirculating type furnace used to draw spring steel bumper parts was completely demolished by an explosion of butane gas. The explosion occurred as the furnace was being lighted. Apparently the pilot light failed and since the electrode also became grounded the gas valve remained open allowing butane to pass through the combustion chamber, out of the charged end of the furnace and to a high heat furnace 30 feet away where it ignited. Fire flashed back through the vapor trail causing the explosion in the furnace. When the furnace was rebuilt, controls were provided to shut off the gas flow automatically if the electrode became grounded.

No. 58. Fostoria, Ohio, Feb. 8, 1951: An explosion that blew out all walls of the 1-story corrugated asbestos on steel frame building and killed the five employees in the building is believed to have involved propane released from a propane-fired machine for case hardening the bearing surfaces of crankshafts. The machine consisted of a series of torches supplied by propane from a vaporizer in an immediately adjacent noncombustible building. The aboveground storage tank was detached 70 ft. Eight minutes after the five men entered the hardening building to case harden a large crankshaft the explosion occurred. The fact that the men did not notice the presence of odorized propane prior to the explosion indicates that a large amount of gas was released quickly.

W. Kankakee, Ill., January 1, 1951. Propane gas, leaking from a buried pipe eight feet from this stove storage building followed sprinkler piping into the building and ignited at a heater in the dry pipe valve enclosure. Concentrated single area storage of 31,500 stoves resulted in a loss estimated to be at least $2,000,000. (See Case No. 61.)

STORAGE OCCUPANCIES

No. 59. Newburgh, N. Y., Feb. 1, 1933: An employee, about to replace the refrigerant in an electric refrigerator in the first floor refrigerator repair room, placed a small tank of iso-butane on a register to warm. When the heat from the register developed excessive pressure in the tank, a defective bolt allowed the head of the tank to blow off before the safety disc ruptured. Fire flashed through the released vapors which are assumed to have flowed through the register and ignited at the furnace in the basement. Three sprinklers held the fire in check in the repair room in the 2- and 4-story wooden building until extinguished by employees using a 33-gallon soda-acid extinguisher. Loss was $16,000.

No. 60. Pocahontas, Ark., Feb. 24, 1948: The human element was an important factor in the explosion of butane gas that killed one person, injured three others and resulted in the destruction of three adjoining buildings. The explosion originated in a 2-story brick, wood-joisted building formerly occupied by a funeral home and theatre. The funeral home premises had recently been vacated and was being used by a hardware store for storage at the time of the blast. A valve on a butane system, left in the building by the previous tenant, is supposed to have been accidentally opened by workmen removing partitions. When a passerby noticed the odor of gas coming from the building the following morning, the building was supposedly locked up and an attendant left to prevent entrance. However, 20 minutes later two hardware store employees entered to inspect a stored washing machine, at which time the explosion occurred. One of the two men reportedly lit a cigarette.

An interesting sidelight is that the excess flow valve on the storage tank functioned satisfactorily when the explosion broke gas system piping.

No. 61. West Kankakee, Ill., Jan. 1, 1951: Propane gas leaking from a buried pipe 8 ft. from the building is believed to have followed underground sprinkler piping into the building where it ignited at a hot plate used to heat a dry pipe enclosure. On discovery of the fire at 11:00 P.M. the watchman gave the alarm and then used hand extinguishers and a hose line in an unsuccessful attempt to prevent flames from spreading through the undivided 1-story brick, steel-frame building loaded with 31,500 oil and gas stoves packed in wood slatted crates and excelsior. The dry pipe valve controlling sprinklers in that part of the building where the fire started had been closed for several weeks because of the need for minor repairs to the system. Fire spread beyond control in the unprotected area and overpowered sprinklers in protected areas. Loss was estimated to be at least $2,000,000.

TRANSPORTATION EQUIPMENT

FREIGHT TRUCKS*

No. 62. near Leeds, Utah, Aug. 3, 1949: While proceeding along U. S. highway 91, the driver of a butane-fueled semi-trailer truck saw flames suddenly come up from the motor. He and his partner jumped from the vehicle while it was still in motion. After continuing out of control for 960 ft. the truck stopped and burned.

No. 63. Bakersfield, Calif., Nov. 25, 1949: While hauling a 22½-ton load of cotton seed, the fuel line broke at the right butane tank behind the cab. Released butane ignited and fire spread to the cab and cargo. Fire was beyond control when fire apparatus arrived.

*See also Garages and Service Stations, LP Gas Bottling and Distribution Plants, and Cases No. 44, 109, 118 and 119.

LP GAS TRANSPORT TRUCKS*

No. 64. Sacramento, Calif., Oct. 13, 1948: Two bystanders were burned to death when a butane tank truck was struck by a train at a grade crossing. The released butane enveloped the area in flames and ignited one of the train coaches. Prompt action by the engineer in pulling the train free of the flames is credited with saving the lives of the coach occupants.

No. 65. Los Angeles, Calif., June 11, 1941: A 2,300-gallon tank truck trailer was being used as a butane storage supply for a road-grading job. All openings on the tank were in the head with the exception of the relief openings, a fusible element having been substituted for relief purposes. The tank was not equipped with excess-flow valves.

The truck was located at the top of an incline, and butane was being transferred to one of several storage tanks by means of apparatus operated from the transmission of the vehicle. Although the brakes were set and a chock block placed beneath one rear wheel, the truck suddenly began rolling downhill, completely shearing the filling and vapor return hoses. The vehicle coasted approximately 150 feet and collided with a large road scraper. Butane was released over a wide area and ignited by an acetylene torch in use nearby. The resulting fire was fed by the contents of a large gasoline storage tank, a diesel fuel tank, and a number of lubricating oil drums that were located a few yards distant. Fire emanated from the butane storage tanks, but no effort was made to extinguish it.

Had the tanks been equipped with excess flow valves such a large amount of butane (approximately 4,000 gallons) could not have been dissipated, and consequently the fire would have been of short duration. Several men were badly burned, though the fire department handled the situation very ably.

No. 66. Hobart, Okla., Nov. 18, 1941: Four persons were severely burned, a home destroyed and three automobiles wrecked when a butane tank truck caught fire and exploded. The fire was the result of a leak in a pipe under the tanks, probably due to the continuous vibration of the truck while en route. The driver was informed of the fire by a passing motorist and when he stopped to investigate, fire enveloped the tanks, thus generating more pressure than the safety valves could release. The explosion blew off the tank heads.

No. 67. Los Angeles County, Calif., Jan. 18, 1943: A butane transport unit comprising a single 4,300-gallon tank mounted on a truck semitrailer was destroyed by fire and five persons lost their lives when leaking butane ignited. The driver had pulled to the side of the road and was found by police attempting to control a large leak of liquid butane coming from a connection from the bottom of the cargo tank. While police were setting barricades to control traffic from the south, a taxicab carrying three sailors approached from the north and stopped opposite the leaking truck. At that moment a flash occurred, burning to death the truck driver, taxi driver and the three sailors. The fire traveled through the previously released vapors for approximately one-quarter of a mile, but since there were no buildings in the vicinity the truck and taxi were the only property damaged.

No. 68. Oklahoma City, Okla., Mar. 31, 1944: Five people were killed and twenty-one injured in a liquefied petroleum gas transport trailer-truck explosion. The resulting fire destroyed a lumber yard, one dwelling, a private garage, shed, a small storage building and an automobile. In all, about 50 properties were involved.

Four tanks were mounted on the trailer; 2 of these, 36 in. in diameter, 30 ft. 8 in. long, with

Oklahoma City, Okla., March 31, 1944. Five persons were killed and 21 were injured by an explosion involving an LP gas transport truck, a lumber yard, dwelling, garage and other buildings. In all, 50 properties were involved. Had relief valves on cargo tanks been arranged to discharge into the open air (instead of into a rear compartment) it is doubtful if an explosion would have occurred. (See Case No. 68.)

Acme

Fort Worth, Texas, February 28, 1946. Welding on a loaded butane tank truck caused this fire. Butane leaking from tank connections ignited. Picture shows hose stream keeping the tank cool so that valve could be closed to stop the flow of gas. (See Case No. 70.)

capacities of 1,526 water gallons each, were butane tanks and were mounted on each side of the trailer. Two propane tanks, 20 in. and 24 in. in diameter, 25 ft. 10 in. and 30 ft. 8 in. long with capacities of 416 and 668 water gallons respectively were mounted one above the other between the butane tanks, the shorter on the bottom.

The truck with 3,866 gallons of liquefied gases in the four tanks was passing a small business district when bystanders saw flames coming from the compartment enclosing the rear of the tanks, and hailed the driver. Eight minutes after the alarm was telephoned the right butane tank exploded. Prior to this, gas had been escaping and burning at the safety valve on the top center of the left tank but apparently the valve on the right tank was not operating. The right tank split along the side throwing flaming butane over a wide area fatally burning two men trying to move a car to safety and injuring 19 firemen. The front end of the tank was thrown through a brick veneered dwelling 183 ft. away. The rear head traveled 70 ft., and the main body 50 ft. The left butane and top propane tanks were hurled 165 ft. and 245 ft. but did not explode, although gas from ruptured fittings continued to burn. The lower propane tank broke in two, one section traveling 272 ft. and the other 518 ft. where it killed three people watching the fire. The lumber yard was involved almost immediately, from where the fire spread to the other destroyed structures.

The cause of the fire was not determined although it appears that the flames at the rear of the truck may have been fed from gas discharged from a leak in a tank or fittings. The burning gases in the enclosed rear compartment would tend to heat the tanks, causing discharge of additional fuel from the propane tank relief valve that discharged into the compartment. Had the propane tank relief valves been arranged to discharge into the open air in accordance with NFPA Standards, it is doubtful if an explosion would have occurred, irrespective of the truck fire.

No. 69. Denison, Texas, Nov. 21, 1944: At a street intersection the front of a 1,000-gallon butane tank truck collided with the rear bumper of an automobile, the impact causing the cargo tank to slide forward a few inches. The rigid L-shaped connection, consisting of several cast iron fittings between the pump and the bottom of the cargo tank, was broken when the tank slipped. One of the breaks occurred at a nipple screwed into a collar in the bottom of the tank. When the nipple broke, the excess flow valve

Wide World

Near Martinez, Calif., March 13, 1949. The driver of this LP gas transport truck is shown trapped in the cab following an accident. Firemen were unable to free him before gas escaping from a broken connection ignited, but with the protection of water spray they were eventually able to effect his rescue. Trucks hauled 115,000 gals. of water to the scene to cool the tank and men during rescue operations. (See Case No. 73.)

dropped out allowing butane to discharge. Ignition occurred about two minutes later when the butane reached the flame of a hot water heater 200 ft. away. Everyone within a radius of 300 ft. was burned, ten fatally. Little fire damage occurred to surrounding buildings, but the wall of one building was bulged out when gas entered and exploded.

No. 70. Fort Worth, Texas, Feb. 28, 1946: While a loaded butane tank truck was being repaired in a vacant lot outside a welding shop butane leaking from tank connections was ignited either by an acetylene torch or welding sparks. More butane escaped and burned as the discharge hose (under pressure) burned through. The alarm was telephoned by the workman without delay but flames had spread to near-by brick and iron-clad buildings before fire fighters reached the scene. Extinguishment was accomplished by keeping the tank cool with water streams and closing the master valve.

No. 71. Louisiana, June 23, 1946: When gas was observed escaping from around the fuel pump beneath the storage tank, the ignition switch was turned off and the truck brought to a stop. Since the driver found that his brakes did not operate, he slowed the truck by shifting into a low gear. Before the truck stopped the escaping gas caught fire heating up the storage tank and causing the relief valve to operate. Gas escaping from the relief valve ignited and shot flames 50 to 75 ft. in the air. The two men in the truck warned highway traffic and occupants of farmhouses to leave the scene as fire destroyed the truck. No explosion occurred.

Investigation revealed that the master valve between the storage tank and the pump had been allowed to remain open causing a back pressure against the pump and the fill line. In some way the packing around the pump or the connection failed, allowing the gas to escape. After this fire, orders were issued by the Louisiana Division of Public Safety, Petroleum Section, that before an LP gas transportation truck is moved, the master valve between the storage tank and pump must be closed.

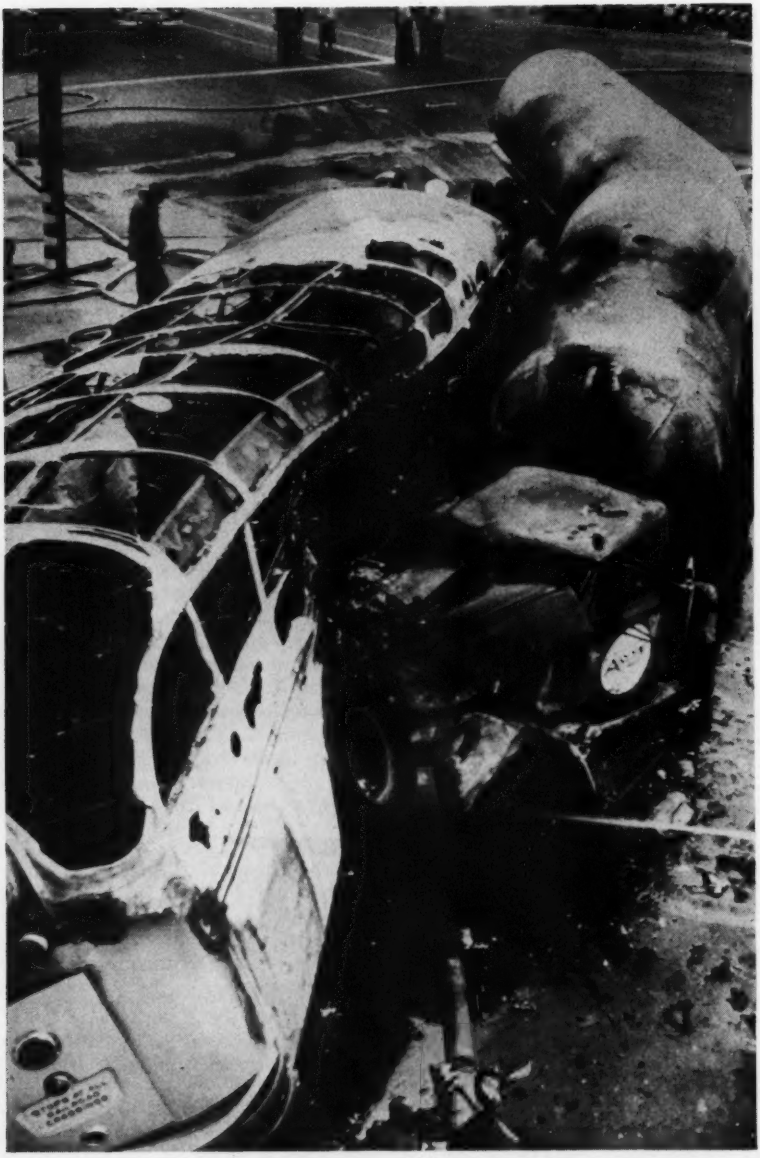
No. 72. near Hope, Ark., Feb. 12, 1947: Collision of a freight truck with a butane tank truck resulted in fire and death to the driver of the tank truck. As a result of the impact, the tank truck rolled over breaking piping on the butane tank. Ignition source of the butane is unknown.

No. 73. near Martinez, Calif., Mar. 13, 1949: Crash of a tractor-type tank truck pinned the driver in the cab, overturned the trailer and broke a connection on the cargo tank just behind the cab. As butane escaped under pressure, firemen, summoned by radio by a passing fire chief, worked frantically but unsuccessfully to free the driver before the escaping gas ignited. After ignition of the gas, firemen continued to work under the protection of water spray and eventually with the help of a tractor wrenched the truck tractor from the trailer and freed the driver. Approximately 115,000 gallons of water hauled to the scene in trucks was used to cool the tank and men during the rescue operations.

No. 74. Wray, Colo., Aug. 23, 1950: While proceeding down a steep grade on a dead end street the brakes failed on a semi-trailer truck on which a two-compartment propane tank was mounted (2,782-gallon water capacity, each compartment). The vehicle failed to make the turn at the foot of the hill, overturning and snapping off an unprotected fill pipe at the top and rear of the tank. When the excess flow valve failed to operate a cloud of propane spread out from the wreck and ignited, possibly at a garage paint shop across the street. Five bystanders were burned, two fatally, in the flash fire, and a dwelling was ignited and destroyed. Fire that enveloped the truck continued unabated until the propane in both compartments (escaping from the broken pipe from the rear compartment and from the relief valve in the front compartment) had been consumed.

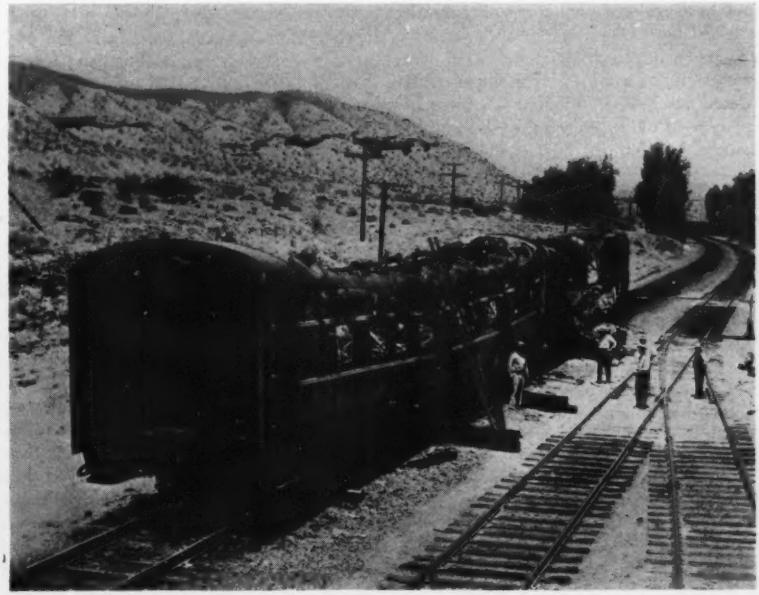
No. 75. San Fernando, Calif., June 14, 1951: An isobutane truck of 6,000-gallon capacity with a 4,000-gallon capacity trailer attached (total cargo 7,000 gallons) went through an intersection red light and collided broadside with an empty school bus. The bus was knocked against an automobile salesroom. The truck driver, who was killed, had apparently dozed at the wheel.

The bus fuel tank, containing between 40 and 50 gallons of gasoline, was torn off by the impact. The spilled gasoline immediately started a severe fire, tires ignited and the diesel fuel tanks on each side of the LP gas truck exploded and added fuel to the fire that had totally involved the bus before firemen arrived. The exposure fire soon caused relief valves on the cargo tanks to open and firemen state that before hose streams were brought into action flames were



Acme

San Fernando, Calif., June 14, 1951. Following collision of the isobutane transport truck with the empty school bus, spilled gasoline from the bus fuel tank ignited, tires burned and diesel fuel tanks on the transport exploded. Flames leaped 60 ft. in the air from relief valves of the cargo tanks but neither tank exploded and firemen were able to attack and control the gasoline and oil fire. With the exposure fires out, the vent fires went out. (See Case No. 75.)



Union Pacific Railroad Co.

Mojave Desert, July 7, 1949. Fire broke out in the air conditioning system of a Pullman car while the "City of Los Angeles" was speeding through the Mojave Desert. Burning LP gas produced such high heat that hard-drawn aluminum structural members of the car were melted. (See Case No. 79; see also October 1949 *Quarterly*, page 104.)

shooting 60 ft. in the air from the vents. Confident that the vents were adequate, firemen used two 1½-inch lines to sweep the oil and gasoline fire from under the vehicles and to extinguish the bus fire before it spread to the salesroom. With the exposure fire out, the tank pressures dropped and the vent fires went out.

No. 76. Baird, Texas, July 19, 1951: While in transit, a relief valve on one of the 616-gallon twin propane tanks opened. The escaping propane ignited from an unknown source and heat from the ensuing fire caused gas to escape and be ignited at the relief valve of the second tank. Both flames burned until the gas supply was exhausted. Inspection after the fire revealed that neither tank suffered serious damage.

PASSENGER VEHICLES*

No. 77. Bell Gardens, Calif., Apr. 11, 1946: Fifteen persons in the butane-fueled bus received first, second and third degree burns (one was also trampled during the rush to escape) when fire flashed through butane gas that had entered the vehicle. The bus had stalled at an intersection. After making repeated attempts to start the motor located in a compartment at the rear, the driver telephoned his office for a repairman and another bus. The flash fire occurred on his return.

From all indications the butane had escaped into the motor compartment from the carburetor and regulator while the driver was attempting to start the motor, and spread through the space between the metal body and interior finish and thence through openings into the passenger compartment. The flash occurred when a passenger in the rear lit a cigarette; however, the gas must have been present throughout the bus as passengers in the front as well as those in the rear were burned.

No. 78. Columbus, Ga., Mar. 13, 1950: A small portable I.C.C. cylinder, filled by use of

*See also Garages and Service Stations and Case No. 108.

the outage gauge on the cylinder rather than by weight had been placed on the back seat of a parked automobile. It is believed that the cylinder was overfilled and the heat from the sun on the closed automobile caused LP gas to escape from the relief valve. When the owner of the automobile entered the vehicle and struck a match to light a cigarette a flash fire occurred that burned him seriously and damaged the automobile.

RAILROAD TRAIN

No. 79. Mojave Desert, Calif., July 7, 1949: Upon discovery of fire that originated in the air conditioning equipment of a Pullman unit (two cars), the train was stopped and the passengers were removed. Since there was no public fire protection available there was no choice but to disconnect the burning unit and allow the fire to burn itself out.

Investigations indicate that the fire was due to a combination of circumstances starting with the disconnection of the generator link to the carburetor of a Waukesha, propane-fired engine. This permitted the engine to overspeed, and in turn, to overheat the exhaust manifold. It is believed that a large section of the check damper at the discharge end of the exhaust muffler had been knocked out and that hot exhaust gases impinged directly on heater pads which during cold weather warmed the three propane storage tanks. Excessive temperatures developed in the heater pads caused sufficient pressure to develop in the tanks to open one or more relief valves, releasing propane which probably was ignited by sparks as brakes were applied. The propane fire produced such high heats that hard-drawn aluminum structural members of the car melted down. The Pullman unit was a total loss. (See October 1949 QUARTERLY, page 104, for complete details.)

WATER CRAFT

No. 80. Marblehead, Mass., May 22, 1940: A violent explosion wrecked a 50-foot cabin cruiser that was fueled by liquefied petroleum gas and operated by a replaceable, two-cylinder assembly of conventional design. One life was lost and damage to the boat and the shed in which it was housed amounted to $3,000.

No. 81. Miami, Fla., Apr. 30, 1944: Thirty-two of seventy people aboard this 52-ft. sight-seeing boat were burned when butane gas exploded in the bilge as the crew was attempting to back the boat from its mooring. The boat was equipped with two 90 H.P. gasoline engines converted for use of butane fuel, one of which failed to start on this first trip after an empty fuel cylinder had been replaced. The explosion occurred on the second attempt to start the motor. Investigation of the fuel system on the day following the explosion revealed that high pressure gas flowed through the pressure regulator without any apparent pressure reduction, then through the carburetor and into the bilge. Examination of the pressure regulator revealed that the valve seat had become dislodged thus allowing high pressure gas to pass through into the low pressure side. Examination of the carburetor revealed that the float valve would not seat properly due to an accumulation of dirt.

No. 82. Jacksonville, Fla., July 8, 1947: Butane being pumped from a tank truck into cylinders aboard a banana boat escaped from a loose tank connection and spread into the galley and No. 1 hold where men were unloading bananas. Two men were killed and two injured in the flash fire that followed ignition of the gas, either in the galley or in the hold where men were smoking. When the discharge hose was pulled free of the vessel fire followed escaping gas to the pier.

GARAGES AND SERVICE STATIONS

No. 83. Spokane, Wash., 1935: In order to demonstrate the merits of a fire extinguisher, about a gallon of liquefied petroleum gas was withdrawn from the storage tank and poured into a flat garage drip pan. There was a delay in lighting the pan. Gas evaporated and spread for a distance of from 30 to 40 feet. A fire flared at once when a match was applied and one man was burned. The obvious cause of the fire was carelessness and lack of knowledge of the characteristics of LP gas.

No. 84. Crowley, La., Oct. 22, 1936: Butane gas escaping from a broken connection on a skid tank was responsible for fire and explosions that killed five people and practically destroyed five buildings.

The owners of the gasoline filling station were also engaged in the retail distribution of

Crowley, La., Oct. 22, 1936. Five persons were killed and five buildings were destroyed as a result of a butane explosion at this service station. During transfer of a skid tank to a platform the discharge outlet broke releasing the butane. (See Case No. 84.)

butane for which purpose they employed a utility truck equipped with a 1,000-gallon skid tank in a wooden cradle. There were four openings: the fill opening near the top; a safety valve in the top; a two-inch discharge outlet equipped with necessary fittings for hose couplings at the rear end; and near the top, a half-inch vapor return line for use when filling underground tanks.

When not in use the tank was transferred from the truck to a platform. Employees were tranferring the tank containing 600 gallons of butane to the platform using a steel cable when the two-inch discharge outlet caught on something and broke allowing butane to flow out and vaporize immediately. Realizing the danger, employees notified the fire department, and warned passersby and people in near-by houses to leave. When the vapors reached a trash burner 162 feet from the tank, fire flashed back to the tank and buildings where four explosions occurred. Five persons in the only dwelling not vacated were seriously burned, four fatally, and a passerby was fatally burned by the flash. Fire totally destroyed three buildings and explosions two others.

No. 85. Wichita, Kans., Feb. 18, 1940: The tanks on a butane transport truck had been drained and the drain plug not replaced before the truck was driven into the garage for repairs. It is believed that the heat generated by the running truck engine in the garage caused the residual gas to expand and escape from the tank. An explosion occurred that demolished the 1,500 sq. ft. one-story wooden building. The employees were under the truck when the explosion occurred and escaped with minor burns.

No. 86. St. Johns, Ariz., Feb. 28, 1942: A butane fuel tank had been removed from a truck prior to work on the truck by mechanics. While the tank was being replaced, a line was broken allowing butane to escape and ignite at a wood stove in the garage. Flames spread rapidly through the garage and extended to other occupancies in the one- and two-story brick, wood-joisted building. In addition to the fuel tank, the truck also carried a 1,500-gallon cargo tank containing 1,200 gallons of butane. Butane from this tank burned and the tank exploded about thirty minutes after the fire started. Loss was $68,000.

No. 87. Dickinson, Texas, Dec. 24, 1942: A butane transport truck, consisting of a tractor and semi-trailer unit on which three storage tanks filled to capacity with 2,800 gallons of butane were mounted, was in the garage for repairs to the tractor. A mechanic was backing the truck out of the garage after the repairs had been made, when the discharge pipe of the center tank came in contact with the discharge pump mounted on the tractor and broke. The break was a small crack in the all-thread nipple near the elbow. Escaping butane exploded causing the death of one man, injuries to others and fire damage to the garage.

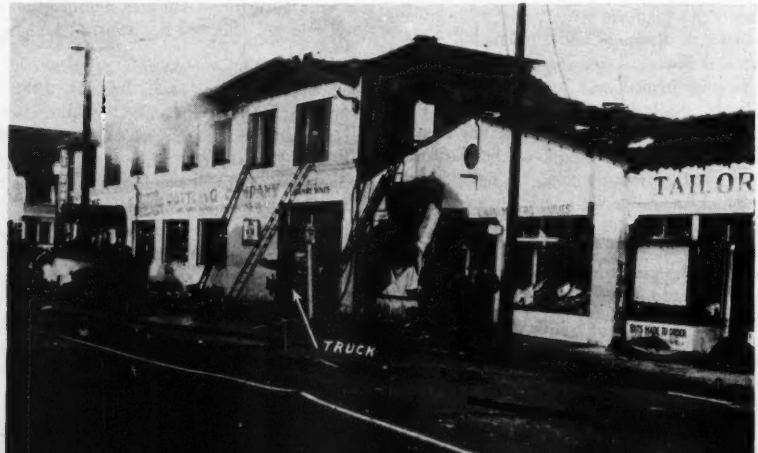
The location of the discharge pipe on the middle tank was such that it was liable to strike the discharge pump mounted on the tractor whenever the truck was turned to the left and there was a sharp dip in the roadway. These were the conditions when the break occurred. The truck had experienced a similar accident six months before while under different ownership.

No. 88. Santa Barbara, Calif., Dec. 26, 1945: Five occupants of second floor apartments in a 2-story brick, wood-joisted building were killed by an explosion of butane gas in the first story occupied by a beer distributor. The building was wrecked. Evidence indicates that a wet valve had been manually removed from the fuel tank of a butane-powered truck stored in the building (possibly by the truck driver who was attempting to start the truck at the time). The valve was found on the sidewalk in front of the building and showed no signs of damage by either the explosion or ensuing fire. One theory advanced is that the leaking butane was ignited by a near-by automatic, open flame, water heater.

On several occasions in the past the odor of gas had been noted by occupants of the second story, and in two instances it had been traced to the butane tank on the truck involved in this explosion. In one instance the heat exchanger had frozen and cracked; in another, one of the tank valves was leaking.

No. 89. Glenwood, Ark., Jan. 28, 1947: Fire that destroyed this unsprinklered 1-story brick, wood-joisted garage was probably caused by ignition of butane gas escaping from an unlighted gas stove in the 336 sq. ft. paint shop. The gas is believed to have ignited at a butane-fired steam cleaner just outside the paint shop. A few days before, the owner had noticed the stove turned on but not lighted. Feeding on paint, thinner, oil and grease the fire spread rapidly through unprotected openings and within five minutes had involved all of the interior and roof.

No. 90. Fairbury, Nebr., Feb. 21, 1948: An explosion demolished this garage and contents, killed one person and seriously injured four. The explosion involved propane released from one of two 40-gallon fuel tanks on a truck in the garage. On seeing a valve on the tank suddenly give way, the garage owner yelled to other occupants to shut off everything, open the doors and get out. Everyone except the owner was outside when the explosion took place, apparently being set off by the coal furnace in a pit about 15 ft. from the truck. The owner was in a back room and was not injured but an employee was just going out the door when the toppling brick wall hit and killed him. No probable cause for the valve failure could be determined.



Santa Barbara, Calif., December 26, 1945. Five occupants of second-story apartments were killed in an explosion of butane gas. The gas is believed to have escaped from a butane-filled truck garaged in the first story. Odor of gas noticed on several previous occasions had been traced in each instance to a leak at the truck fuel tank. (See Case No. 88.)

No. 91. Magnolia, Ark., June, 1948: An em-oyee of a near-by LP gas company hauled a 500-gallon skid tank to the garage to have it amed out because oil had accumulated in the nk. The employee and a garage attendant aced the tank 10 feet from an open fire and lieving the tank to be empty opened one of e valves. Residual gas escaping from the tank s ignited by the fire severely burning both men.

No. 92. Charleston, Mo., Dec. 30, 1950: An plosion heard by most of the townspeople at 00 A.M. gave the alarm for fire that destroyed s unsprinklered 2-story brick, wood-joisted ilding. In the opinion of the fire chief, the plosion involved butane leaking from one of o butane-fired unit type heaters in the build-g. One of the heaters had given trouble dur-g the two days prior to the explosion. A re-ir man had supposedly corrected the trouble.

No. 93. Franklin, Ky., Mar. 19, 1952: An explosion of butane vapors blew out the concrete block walls of the 1-story garage allowing the roof to fall in. Fortunately none of the five occupants was seriously injured. About 25 separate fires broke out but all were extinguished with relatively minor damage.

At the time of the explosion mechanics were removing a leaking half-full fuel tank of about 15 gallons capacity from a butane-fueled tractor. The fuel and vapor lines had been disconnected but the valves were left open. According to reports, the mechanics hoped to decrease the weight of the tank by allowing butane vapors to escape through the open valves. The vapors were apparently supposed to leave the building through the open garage doors. A gas heater in the garage office was the probable source of ignition.

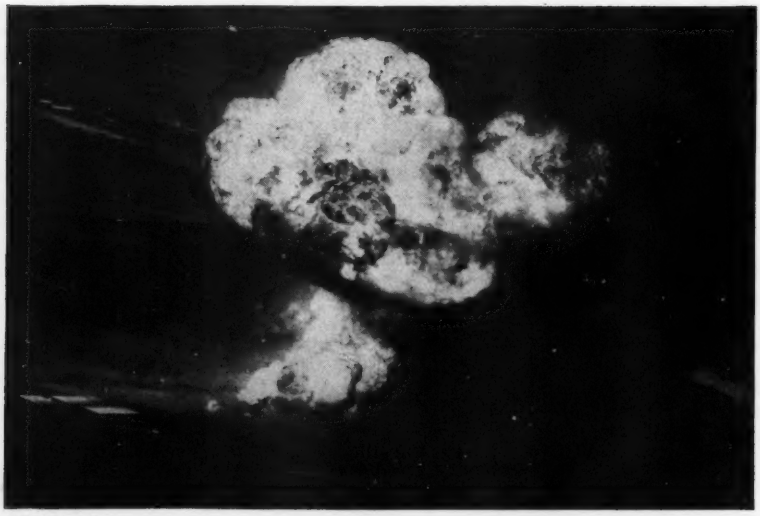
LP GAS BOTTLING AND DISTRIBUTION PLANTS

No. 94. near Lubbock, Texas, May 1, 1940: hile employees were filling butane tanks (bot-s) vapors escaped and apparently ignited at electric motor. Failure of safety plugs to re-se caused 20 tanks exposed by the intense fire explode. Of these, 12 ruptured and 8 strip-d threads and blew off valve assemblies.

No. 95. Adams County, Colo., June 25, 1940: persons were injured and the small bottling nt and an exposed grocery store were de-oyed by explosion and fire that occurred while o propane cylinders were being filled in the nt through a manifold from a tank truck in yard. While the tanks were being filled the xible hose connection to one of them broke oding the building with propane gas. The at-dant went outside to close the valve at the k truck and was re-entering the building to p the filling pump when the explosion oc-red. The ignition source is believed to have en a gas-fired household refrigerator in opera-n in the building for demonstration purposes. operty loss was $11,700.

No. 96. Covington, La., Oct. 16, 1941: A tank ck was being filled from a storage tank, a trifugal pump being used to hasten the opera-n. The engine carburetor was not equipped th a flame arrestor, and though the equalizer se was connected to the top of the truck the

Near Lubbock, Texas, May 1, 1940. Failure of safety plugs to release caused 20 tanks exposed by fire in a LP gas bottling and distribution plant to explode. Of these, 12 ruptured and 8 stripped threads and blew off valve assemblies. (See Case No. 94.)



International

No. 129. Newark, N. J., July 7, 1951. A severe fire followed by a number of explosions of propane storage tanks, demolished a group of 70 propane storage tanks (each 70 ft. long and 105 inches in diameter). Three tanks in another group 350 ft. away were also involved. Evidence indicates that the fire was caused by a break in a liquid pipe or fitting near the ground in the tank group where first discovered. A minor explosion occurred three minutes later followed in 10 minutes by a violent explosion. For the next two hours tanks exploded at 2- to 3-minute intervals. One tank landed on a filling station over ½-mile away. Another broke a water main, depriving the area of water until fireboats pumped into mains. Total loss was estimated at $1,050,000. For detailed report see July-August, 1951, "Fire News."

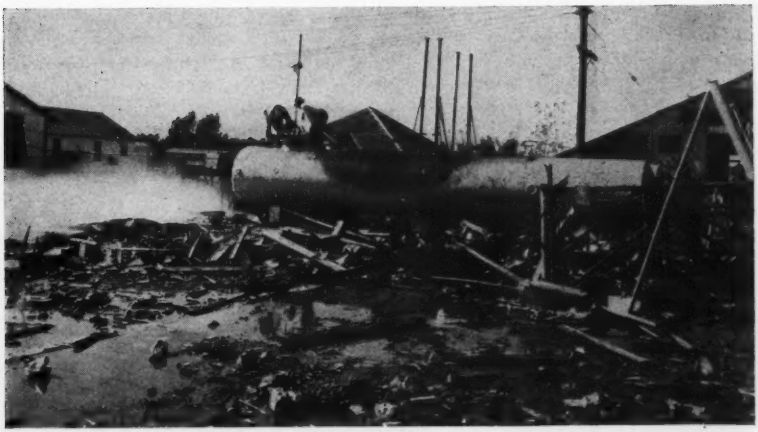
end intended for connection to the tank was left on the ground. The escaping vapor was ignited, according to the truck driver, by a backfire at the carburetor, but ignition may have occurred at the engine magneto contacts or at the exhaust. A flash fire followed and burned two persons. Carelessness on the part of the driver, use of substandard pumping equipment, and haste were the reasons for the accident.

No. 97. Bremen, Ga., July 30, 1943: While butane was being transferred from a transport truck to a storage tank a leak, apparently unnoticed, occurred at a connection. Escaping gas flowed to the pump house and was ignited. A spark from the electric motor for the pump was a possible ignition source. The fire burned for some time before an explosion occurred.

No. 98. Big Bear Lake, Calif., July 18, 1946: Three summer resort cabins and a large 1-story metalclad warehouse were destroyed by explosions of butane gas that escaped from piping at a butane distributing plant. The pipe which broke as employees were filling a tank truck is believed to have been loosened by an earthquake earlier in the day. Escaping butane spread in all directions over a 2-acre area and exploded on reaching a flame in one of the cabins. In quick succession explosions also occurred in two other cabins and in a warehouse. There were no fatalities but one elderly man was badly injured.

Firemen kept hose streams on one 4,000-gallon and one 2,000-gallon storage tank during the fire and prevented their destruction.

No. 99. Corpus Christi, Texas, Dec. 5, 1946: An explosion that occurred at 7:32 A.M. as an employee was in the process of lighting a butane-fired stove in the one-story hollow tile, reinforced concrete office and salesroom building disintegrated the building and leveled an adjacent one-story metalclad laundry. Two em-



Corpus Christi, Texas, Dec. 5, 1946. Two buildings were leveled and two occupants killed by an explosion that appeared to originate in the salesroom of an LP gas distributor. Ensuing fire was confined to gas released from two 5,000-gallon aboveground LP gas storage tanks. Water spray from two hose lines was directed on the tanks until their contents (2,000 gallons each) were consumed. (See Case No. 99.)

loyees in the laundry were killed by the blast nd 17 persons in the vicinity injured. Two wellings in the immediate neighborhood were endered untenable, and several other buildings ithin a 5-block area suffered structural damage nd glass breakage. Glass was shattered four iles away.

After a delay caused by wrong telephoned irections by an excited housewife, firemen ar- ved and laid eight lines as a precaution against n outbreak of fire. Fire was confined to butane as being released as a result of the explosion om two 5,000-gallon storage tanks located boveground behind the fuel company building. Vater spray from two hose lines was directed at ese tanks until their contents (2,000 gallons ach) were consumed. The tanks were then lled with water.

Following an extensive investigation into the ause of the blast, a report of the Fire Marshal ontained strong evidence that ignition of butane as accumulation was a probability. The pos- ibility that natural gas, supplied by street main o the laundry, had in some way entered the fuel ompany building in explosive quantities, al- nough improbable, could not be eliminated. The probability that leaking butane gas caused he explosion was supported by the fact that ubber hose connections were used at the five outlets within the building, that on numerous occasions odorized butane gas had been detected at neighboring residences, and that careless practices of employees of the fuel company, although contrary to the management's policy, had been observed.

No. 100. Spencer, W. Va., Sept. 29, 1947: While propane was being transferred to cylinders from two skid tanks in the loading room of the 2-story brick, wood-joisted plant, one of the skid tanks tilted breaking a fitting. As escaping gas flowed down a slight incline toward near-by dwellings, gas company employees went through the neighborhood warning people to extinguish all flames. However, before one aged man in a house 130 ft. from the bottling plant had fully complied, the gas reached his home and exploded.

This explosion and a second at the bottling plant wrecked the dwelling and the plant, severely damaged another dwelling and a garage and caused minor explosion damage to other homes in the neighborhood. Heat radiation from the ensuing fire in the bottling plant ignited the rear of a dwelling 28 ft. away.

Prior to the explosion citizens of the town had opposed the presence of the bottling plant. As a result of their protests after the explosion, the plant was moved outside the city limits.

No. 101. Chattanooga, Tenn., Feb. 8, 1948: Employees repairing a leak at the pump on a tank truck had headed the truck into the rear doors of the 40-ft.-sq. Quonset type repair shop to afford protection against inclement weather. About 500 gallons of LP gas was in the cargo tank. Apparently gas from the leaking pump spread to a hot water heater in the shop, since an explosion occurred blowing off part of the roof, bent structural members and blew out plate glass windows. Fire ensued but was extinguished by the three employees using first aid extinguishers before the fire department arrived. Two of the three men were burned. The effect of the blast was lessened because the rear shop doors were open.

Wide World

Palmer, Mass., August 10, 1949. Operation of safety valves on two 18,000-gal. above-ground propane storage tanks prevented their explosion during a propane bottling plant fire. The column of flame in the picture was fed by gas escaping from tank safety valves. Certain features of the installation at this plant, not in accordance with NFPA Standards, have been reported as responsible for the start of the fire and the extensive damage. (See Case No. 104.)

Des Moines

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No. 102. explosion in the bottling near-by dwel fires were se fragments. S killed, the ca

No. 103. employees we gallon housel the loading manager cou sions. The r wooden office age tanks we were not inv ders was hur pedestrian.

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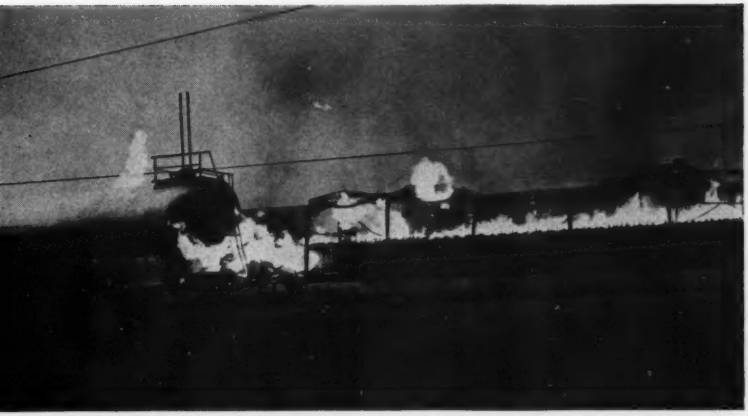

Des Moines Register & Tribune

Near Des Moines, Iowa, April 9, 1950. Lightning caused this fire that destroyed the cylinder charging building and adjacent appliances storage building. Gas burning at the end of a 30,000-gallon storage tank is shown at left. Gas is escaping from leaking valve packing at the exposed end of the tank approximately 10 ft. from the charging building. (See Case No. 106.)

o. 102. Lawrenceville, Ill., Apr. 28, 1948: An losion in the cylinder filling room wrecked bottling plant and set fires that destroyed a -by dwelling and barber shop. Small roof were set at several buildings by flaming ments. Since the only man in the plant was ed, the cause could not be determined.

o. 103. Reno, Nev., Aug. 16, 1948: Three loyees were injured when two of several 50- on household cylinders they were filling on loading platform exploded. The company ager could give no reason for the explo- s. The resulting fire destroyed the 1-story den office and garage, but aboveground stor- tanks were kept cool with hose streams and e not involved. One of the exploding cylin- was hurled 300 ft. and narrowly missed a estrian.

o. 104. Palmer, Mass., Aug. 10, 1949: A k in a 2-inch copper pipe carrying liquefied ane under 250 lbs. per sq. in. pressure was ewed by fire that destroyed the bottling plant severely damaged the building and equip- of a metal pipe manufacturing plant on ining property. Substandard features re- sible for the start of the fire and the exten- damage included failure to maintain a mini- of ten-foot space between the two 18,000-gallon aboveground storage tanks and the bottling plant; installation of the tanks within 50 ft. of the adjoining property; use of ordinary sweated solder joints on copper pipe; use of a combustible building for a bottling plant.

On hearing gas escaping from a joint in a 2-inch overhead pipe outdoors, employees closed the valve at the pump house. Vapors that accumulated during the 1½ minutes required to close the valve burst into flame, severely burning two employees and igniting the combustible bottling plant. Propane from the 80 ft. of pipe from the valve to the break plus gas escaping through spring loaded relief valves on cylinders in the building intensified the fire and caused sweated joints on top of an adjacent storage tank to loosen. Relief valves on the storage tanks operated, and, when gaskets under manhole covers burned out, more vapor escaped and burned.

On arrival firemen found both the bottling plant and the 1-story concrete block pipe manufacturing building in flames. Firemen brought the fire in the exposed building under control in an hour, by which time the fire at the bottling plant had subsided sufficiently to allow use of hand lines on the building and fog nozzle deluge guns on the tanks. Vapors continued to burn at the tank vents for 8½ hours.

No. 105. Winthrop, Mo., Oct. 27, 1949: While a tank car of LP gas was being unloaded unattended, employees of a gasoline station near by heard gas escaping and saw clouds of white vapor around the pump house. They immediately called an employee of the gas distributing station who drove to the station to investigate. When the latter, carrying a lighted flashlight, walked around to the back of the pump house where the unloading hose was connected to the unloading line, a flash fire occurred. The employee was fatally burned.

No. 106. near Des Moines, Iowa, April 9, 1950: Lightning struck the paint room in the unrodded 1-story concrete block, steel-framed cylinder charging building igniting a barrel of lacquer thinner. Flames spread through an open doorway to the cylinder charging area where intense heat opened relief valves on many of the approximately 800 gas-filled cylinders allowing the gas to escape and burn. The cylinder charging building and the adjacent appliances storage building, to which fire spread through exposed wooden doors, were destroyed. Gas escaping from a leak at valve packing at the exposed end of a 30,000-gallon storage tank approximately 10 ft. from the charging building burned throughout the fire. Gas also escaped and burned from the relief valve on a 1,000-gallon tank truck. Since the plant was located outside the city limits and no agreement had been made to have the Des Moines Fire Department respond in case of fire, there was no fire fighting.

No. 107. near St. Elmo, Ill., Feb. 8, 1951: Explosion and fire were fortunately *avoided* when 9,500 gallons of butane escaped from a 14,000-gallon aboveground storage tank. Water from heavy snows and rain settled around the discharge pipe and the low temperatures that followed froze the water, apparently causing the heavy gauge, double duty pipe to crystalize and break at a joint. The excess flow valve failed to operate and butane escaped into the atmosphere. All possible ignition sources in the area were removed until the cloud of gas had blown away. A train passed through the cloud before it could be stopped, but did not ignite the gas.

MISCELLANEOUS OCCUPANCIES

BUS, TRUCK TERMINALS

No. 108. Long Beach, Calif., 1939: Fire broke out under the hood of a bus operated by liquefied petroleum gas. The fire burned steadily until the valve at the supply tank was turned off. Damage was slight, but the importance of employees having complete knowledge of the tank design and operation, especially of location of the shut-off valve, was clearly indicated.

No. 109. Minneapolis, Minn., May 24, 1944: One man died of burns and six others were injured when a truck (tractor) fueled with butane gas struck a door tearing off the fittings of the butane tank. Sparks from an air compressor motor ignited escaping gas.

No. 110. Warrenton, Mo., Nov. 15, 1946: Immediately after being filled with butane a 1,000-gallon underground storage tank exploded spraying butane on the 1-story, 200 ft. by 100 ft. masonry, wood-joisted bus station with restaurant. The building immediately caught fire. Two persons were killed, five injured and the building destroyed. The coroner stated that the exact cause of the explosion "probably never will be known, but it probably was due to too much pressure in the tank or a weak spot." The fire chief's report criticized the proximity of the tank to the building. Property damage was estimated at $25,000.

CHURCHES

No. 111. Gramling, S. C., Apr. 1, 1948: Following an explosion of liquefied petroleum gas in the basement, fire destroyed this 1-story wooden church. The gas is believed to have escaped from an open stove burner. The sexton and his wife who were in the building at the time were injured by the blast. Loss was $30,000.

No. 112. Marion, S. D., Apr. 10, 1949: Six parishioners were killed and 50 injured when an explosion of liquefied petroleum gas in the basement wrecked the 1-story brick, wood-joisted church prior to 9:00 A.M. services. The gas-fired furnace had been shut off earlier in the morning when the janitor smelled gas and found the pilot light out. The explosion occurred when one of the parishioners, who had sold the

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Marion, S. D., April 10, 1949. Six parishioners were killed and 50 injured when an explo-sion of LP gas in the basement wrecked this church prior to 9:00 A.M. services. The explosion may have been due to any one of a combination of the following: 1, improper installation and maintenance; 2, leakage around manual control valve; 3, loose connection to valve controlling 100 per cent shut-off. (See Case No. 112.)

installation, went to the basement to light the furnace. In the opinion of the State Fire Marshal Department the explosion may have been caused by any one, or combination, of the following: 1. improper installation and maintenance; 2. leakage around manual control valve; 3. loose connection to valve controlling 100 per cent shut-off.

It was found that the furnace had been installed by one man, the duct work done by another firm, the wiring and pipe work by still another, and the gas furnished by a dealer from a neighboring town. Some trouble had been experienced with the installation and while qualified servicemen had worked on the unit there had also been unqualified men called.

It is the opinion of the State Fire Marshal Department that had the furnace been installed and maintained by a qualified serviceman and operated as a 100 per cent automatic furnace instead of part automatic and part manual, and had the persons who detected the odor of gas in the basement opened all doors and windows and kept the people from the church until a qualified serviceman had checked the unit, this disaster might have been averted.

DANCE HALL

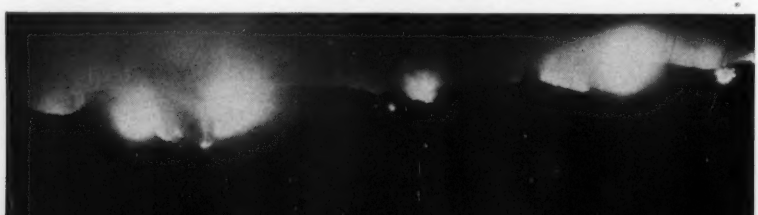
No. 113. near Fredericksburg, Tex., Dec. 25, 1947: During an argument between two inebriates, a butane floor heater was knocked against cardboard sheathing of the unsprinklered 4 000 sq. ft. 1-story metalclad dance hall. The fire started at 7:45 P.M. near the rear of the hall and spread so rapidly over combustible interior finish and paper Christmas decorations that four of the 30 occupants were unable to reach either of the two exits, both located at the front of the building. These four died. In the opinion of the fire chief, the list of fatalities would have been much larger had the fire occurred at a later hour. There were 1,000 reservations for the evening's dance. The building was located outside the city limits of Fredericksburg and was therefore not subject to that city's safety regulations.

FOREST

No. 114. Wheeler's Hot Springs, Calif., Sept. 12, 1948: Fifteen thousand acres of timber, 17 dwellings, an orchid farm and other property were destroyed by fire caused by the failure of a butane vaporizer at a resort hotel. The vaporizer was located in a small metalclad building 25 ft. from the 1,200-gallon storage tank and consisted of a 30-gallon water heater with a butane vaporizer coil installed in the water tank. The vaporizer coil had become corroded to such an extent that gas escaped into the water in the tank and vented to the atmosphere through the water overflow. The escaping gas ignited at the main burner on the pilot on the heater throwing a flame 20 to 40 ft. into the dry foliage of an oak tree overhead. From the tree, fire spread to the surrounding brush-covered land.

JUNK YARD

No. 115. Springfield, Mass., Oct. 18, 1949: Finding three abandoned liquefied petroleum gas cylinders, a junk dealer loaded them in his truck and drove home. Outside his house he removed a tank cap from one of them and was



Los Angeles Times

Wheeler's Hot Springs, Calif., Sept. 12, 1948. Liquefied petroleum gas escaping from a corroded vaporizer coil ignited and threw flames 30 feet into the foliage of an oak tree overhead. Flames spread into brush and before being controlled burned over about 15,000 acres and destroyed 17 dwellings, an orchid farm and forest improvements. (See Case No. 114.)

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Greenville, S. C., November 19, 1946. A propane gas explosion followed by fire killed six persons and caused this wreckage at a laundry. The gas escaped from piping on the high pressure side of the distribution system. Employees were unable to close the tank valve to stop the flow. (See Case No. 116.)

ayed with vapor of liquefied petroleum gas. carried the container inside, set it down in a floor room and went to the basement kitchen ere his wife and another woman were seated. he approached the stove a mild explosion urred setting the junk dealer's clothing afire burning the two women. Flames immeely followed a gas trail back to the cylinder the first floor where a violent explosion urred.

LAUNDRY

lo. 116. Greenville, S. C., Nov. 19, 1946: Six ple were killed and 150 injured when a proe gas explosion wrecked a laundry and damd neighboring buildings. A 6,000-gallon pane tank had recently been installed in the ndry yard to supply boilers. An employee covered a propane leak at about 6:00 P.M. notified the manager who ordered the buildevacuated and called the fire department. An empt was made to shut off the flow of gas, the valve at the tank could not be closed and ployees fled. No means was available for omatic or remote control of the escaping gas. The explosion occurred at 6:27 P.M. The ndry was demolished and nearly all buildings within 300 ft. were damaged. Windows a mile away were broken and chimneys weakened. Fire in the laundry wreckage and in three near-by dwellings followed the explosion. Failure of some parts of the piping in the high-pressure side of the distribution system caused the accidental release.

Although the 50-ft. minimum distance to buildings for tanks over 1,200 gallons was not observed at this installation, the presence of an explosive mixture at considerably more than 50 ft. from the tank indicates that the explosion might have occurred even had the minimum distance requirement of the NFPA Standards been followed.

LUMBER YARD

No. 117. Lexington, Nebr., Aug. 20, 1947: An incendiary fire originating in a lumber yard was being confined to the yard when a series of explosions involving 15 cylinders of liquefied petroleum gas stored on a wooden platform forced firemen to retreat. Hose lines were again brought into position as soon as the threat of further explosions had diminished. During the brief period of enforced inactivity, however, firemen lost control of the flames which spread to

an adjacent furniture store and jumped to and destroyed four other small mercantile structures. Loss at the lumber yard was $50,000; loss at exposed property totaled $290,000.

OIL REFINERIES

No. 118. Huntington Beach, Calif., June 2, 1934: A 5,000-gallon truck was being loaded with butane by gravity through a closed system from a vertical 15,000-gallon storage tank by means of a three-inch line. The vapor spaces of the storage tank and the truck tank were interconnected by means of a one-inch pipe and one-inch hose so as to equalize the pressure, which was 65 pounds, and permit the return flow of the gas. These tanks, however, had no excess-flow valves installed.

The hose in question was of new synthetic rubber, but it had not been tested after the couplings had been applied, and appears to have blown off the coupling nipple in some unknown way. The valve at the base of the storage tank was shut, but the hydraulic internal valve of the tank truck unfortunately was not. The butane vapor that was released was at first like a heavy frozen fog. Five minutes later a flash occurred, igniting six surrounding derricks, five crude oil tanks, part of a small residence, the chassis of the tank truck and some fittings on the adjoining casinghead tanks.

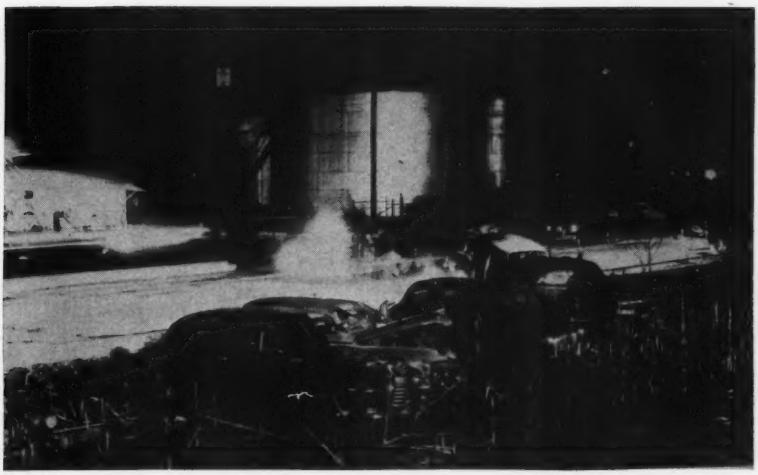
All of the tanks involved, other than those containing crude oil, were pressure tanks with adequate relief valves, plus frangible disks or fusible reliefs. These all functioned as designed, none of the tanks blew up, and the vent fires were extinguished by water shortly afterward. Estimated loss: $50,000 to $100,000.

No. 119. Laredo, Texas, Oct. 11, 1945: A tank truck was discharging butane into a storage tank when sparks from an exhaust pipe ignited a leaking connection between the tank and the truck. An explosion occurred which ignited a number of tank trucks near by, as well as the office and warehouse building, 50 ft. away. The driver of the tank truck ran fourteen blocks to telephone the alarm. The office telephone was not available as the office was locked.

When the first fire companies arrived, the fire was burning between the storage tank on a concrete base and the tank truck. Attempts to extinguish the fire with water from a fire department booster tank had almost succeeded when the water tank was exhausted and three severe explosions in rapid succession spread the fire throughout the property as a hose line was being laid to the nearest hydrant 4,000 feet away. The fire department reports that because of the hazardous nature of the product, this plant had been forced to locate on the outskirts of the city where no fire protection was available.

Dawson County Herald

Lexington, Nebr., August 20, 1947. When this picture was taken fire was confined to a lumber yard. However, explosions among 15 LP gas cylinders stored on a wooden platform forced firemen to retreat. When the danger of explosions had diminished and hose lines were again brought into position, the fire had spread beyond control and eventually destroyed five near-by stores. (See Case No. 117.)



Acme

Texas City, Texas, October 18, 1948. Seven persons lost their lives and 14 were injured when fire flashed through a low hanging cloud of LP gas released from a pipeline. Most of the casualties involved motorists when cars entered the gas cloud and stalled. (See Case No. 121.)

No. 120. Detroit, Mich., Dec. 30, 1949: Struc-al failure of a sheet steel water settling tank 5 ft. long and 3 ft. in diameter) allowed ap-oximately 780 gallons of a butane-propane xture to escape. In the ensuing explosion and e, five employees lost their lives, two were in-ed and a large area of a catalytic cracking nt was set afire. The fire was brought under ntrol in approximately 45 minutes by closing accessible valves and applying water spray d foam. However, the butane-propane mix-e burned for several hours at pipe breaks til diverted by manipulation of valves to a ge open field where the gases burned specta-larly but caused no damage.

The water settling tank and other equipment cleaning the liquefied petroleum gases had en temporarily placed out of service for six urs and were being restored to operating status en the rupture occurred. Investigators were the opinion that the settling tank was not gineered to meet the demands placed on it der the conditions found in this case, and that failure was due to unusual stresses and rations occurring as the tank was being put k in service.

When valves were opened introducing liquid der high pressure into the tank, water ham-mer, turbulence at valve restrictions and vibra-tions set up when the hot liquid discharged into the cooler liquid all may have set up stresses that caused the tank to rupture.

PIPELINE

No. 121. Texas City, Texas, Oct. 18, 1948: Two almost simultaneous breaks in a 6,800-ft.-long 3-inch pipeline used for transfer of a pro-pane-propylene mixture (under 250 lbs. pres-sure) from a refinery to a chemical plant formed a low hanging cloud of approximately 68,000 sq. ft. area that drifted over the Texas City to Galveston highway. Several automobiles, which had been stopped at a grade crossing at the time of the breaks, on being allowed by the crossing tender to proceed, entered the gas cloud a short distance along the road and stalled. Some of the car occupants realized the danger and ran to safety. One man tried to push his car from the cloud and had moved the vehicle about 50 ft. when the cloud ignited. He and six others lost their lives and 14 were injured in the flash fire.

One break occurred at a cast iron tee and the other 748 ft. away at a cast iron pipe collar. Both are believed to have been caused by ten-sion in the pipeline. The breaks occurred in the early evening. Since 11:00 A.M. no liquid had

flowed through the pipe during which time the pressure increased from 250 lbs. to 325 lbs.

SCHOOL

No. 122. Puerto Deluna, N. Mex., Apr., 1946: Leaking butane gas filled the basement of an adobe school building heated by a floor furnace supplied by piping through the basement from an outside tank. The gas accumulation was ignited when one of three men entered the building on the ground floor and lit a match. The ground floor (2 in. by 12 in. joists) was blown out of position, every window in the building was blown out and all three men, one seriously burned, were blown several feet clear of the building. Fortunately, the school was not in session and thus no children were killed or injured.

SHIPYARDS

No. 123. Bayonne, N. J., Nov. 10, 1932: An explosion and fire occurred in a 46-foot cabin cruiser housed in a three-story frame building that was nearly filled with other motor boats. A plumber, engaged in disconnecting water pipes, etc., is believed to have struck a spark in lifting a brass-bound hatch cover in the cruiser's floor. Propane was the fuel used in the boat's small stove and though the propane tank had been removed, it is thought that some of the gas had leaked out previously. The resulting explosion blew the roof off the engine room, raised the roof of the cabin, and in the flash fire that followed, burned the plumber. Four sprinklers in the building operated, and these, with two lines of hose used by employees, extinguished the fire within a few minutes. The loss was settled for $10,000.

No. 124. Chester, Pa., Dec. 31, 1936: Two shipyard workers were killed and twenty were injured when a tank of propane gas located between two shipways exploded. The explosion occurred when a match was struck by one of the employees lounging around waiting for the starting whistle. Leaking gas ignited.

No. 125. Camden, N. J., Dec. 22, 1944: Ignition of an oil slick on water in a way started fire that spread to wood decking on this way and one other. When fire reached the storage area for propane and acetylene cylinders about 30 exploded. Loss was estimated at $75,000.

No. 126. Portsmouth, Va., Mar. 12, 1951: Four employees were working on an LCM landing craft in a 99,000 sq. ft. metalclad building, when an explosion occurred that demolished the engine room of the LCM and pilot house. Two of the employees were killed in the blast; the other two seriously injured.

While entering the engine room an employee heard a hissing sound and discovered an unlit heating torch with the oxygen and propane valves partly open lying on the floor where it had fallen or been knocked from the deck above. The employee immediately shut off the valves and removed the torch but detected an odor of gas that had settled in the area. Soon after, while the employee was watching two fellow workers checking a flotation tank in the engine room, an explosion occurred.

Investigation revealed that the oxygen and propane had been escaping into the engine room for 2 hours prior to the explosion. Although the torch had not been used during this two-hour period, the manifold valves at the connection of the torch hose to the shop's LP gas and oxygen distribution system had been open, contrary to shipyard regulations. Possible ignition sources included smoking materials, electric arc from an extension light or a spark struck by the tools in use by the employees.

Fire that followed the explosion was extinguished by employees and the plant fire department.

TURKEY RANCH

No. 127. Zephyr Hills, Fla., Sept. 1, 1949: A torch used for burning off pinfeathers was connected by a 50-foot rubber hose directly to a 20-pound cylinder of LP gas without a reducing valve or regulator.

When the cylinder was brought into the building, after being filled from a tank truck, gas escaped and was ignited by a pilot light of an automatic water heater. The resulting explosion injured five employees.

EDITOR'S NOTE: **No. 128**, see photo and caption, p. 46; **No. 129**, see photo and caption, p. 72.

Extinguishing Oil Tank Fires by Agitation*

By J. L. Risinger

Safety and Fire Protection Supervisor, Socony-Vacuum Oil Co., Inc.

The mechanism of extinguishment or control of oil storage tank fires by agitation can be readily understood if one basic fact about flammable liquid fires is remembered: burning can take place only when flammable liquid vapors and oxygen are both present above the liquid in correct amounts to form a combustible mixture. Conversely, it is axiomatic that flammable liquid fires must be extinguished when the vapor-oxygen mixture becomes noncombustible. This principle governs every method now in use for oil fire control—including the agitation process.

Extinguishment of oil fires by inert gas is accomplished primarily by reducing the oxygen content below that necessary to form a combustible mixture. Extinguishment by foam or water spray is accomplished essentially by excluding oxygen and reducing the release of vapors below the minimum amount necessary to form a combustible mixture. The agitation process also causes fires in oil storage tanks to be extinguished or controlled by reducing the oil vapor concentration below the lower limit of flammability, but, differing from the conventional methods, accomplishes this by rearranging the contents of the tank of burning liquid rather than by addition of a smothering agent to the surface or by removal of heat.

Simply stated, in the agitation process the hot upper strata of burning liquid (which obviously must be at a temperature above its flash point) is broken up and to a large extent replaced by cooler oil from the lower part of the tank. Fires involving oils having flash points above their storage temperature and having low viscosity, such as kerosene, can be completely extinguished by agitation. The agitation process as a means of controlling fires in high viscosity oils has not been thoroughly explored. Probably some oils whose flash points are not far below their storage temperatures may be controlled, if not extinguished, by agitation so that complete extinguishment can be accomplished by the conventional cooling and smothering methods, using less agent and a lower rate of application than would normally be required.

Socony-Vacuum Research Program

At the present time research is being conducted by the Socony-Vacuum Oil Company Inc. on the following two phases of the agitation process:

1. Complete extinguishment of tank fires involving oils with flash points above their storage temperatures.

2. Reduction of intensity and rate of burning of typical crude oil fires (flash points below their storage temperatures) as well as elimination of slop-over so that extinguishment can be accomplished with less difficulty.

It is planned to extend the research pro-

*This article summarizes an address presented by Mr. Risinger at the 1952 NFPA Annual Meeting. Mr. Risinger's talk consisted primarily of explanatory comments on a colored motion picture record of tests conducted under Mr. Risinger's direction by Socony-Vacuum Oil Co., Inc. (Program Item 57.)

gram to include study of the effect of agitation on fires in low flash point refined oils and to investigate the use of agitation to prevent crude oil boil-over.

Tests on Kerosene Oil Fires

In the first phase of the research program—extinguishment of tank fires involving oils with flash points above the temperatures at which they are normally stored —kerosene distillate of the following analysis was used:

Gravity API	47.4
Specific gravity	0.7909
Weight per gal. (lbs.)	6.585
Saybolt color	9
Saybolt thermo viscosity	326
Flash point °F (tag)	126
Pour point °F	below minus 30
Reid vapor pressure psi	0
Distillation Range	
Initial B. Pt.	334°F
10%	356
50%	400
90%	468
Final B. Pt.	522

Kerosene Tests in 30 ft. by 25 ft. Tank

Following preliminary tests in an 8-ft. pit of kerosene, two large scale tests were conducted in a 30 ft. by 25 ft. steel tank. This was an old tank and plates were approximately half their original thickness. The 100,000 gallons of kerosene distillate used in the tests left a freeboard of about 7 ft. A 9-in. water bottom was beneath the approximately 17 ft. of kerosene.

Test 1. In this test air was injected into the tank by means of the 3-in. water draw-off at the rate of 50 cfm. Air was released into the draw-off at 7 psi through a ½-in. valve 140 ft. from the tank. Preburn time from ignition to entrance of air into the tank was 1½ minutes and time of extinguishment was 30 seconds. Cold subsurface oil that extinguished the fire first appeared on the surface as a bulge adjacent to the shell and from there flowed across the surface of the tank. Extinguishment was completed when the oil reached the opposite side. See photos A, B and C.

Photo A. Test 1, Kerosene. Photo taken during preburn.

Photo B. Test 1, Kerosene. Fire is out 30 seconds after air injection.

Test 2. In Test 2, air was injected into a simulated product line leading to the center of the tank with the ell at the end turned down. Following a preburn of 2½ minutes, air was injected into the tank at a rate of 75 cfm and 6 psi. Allowing a few seconds for the air to displace oil from the product line the time required for extinguishment was only 5 seconds. The short time required for extinguishment in this

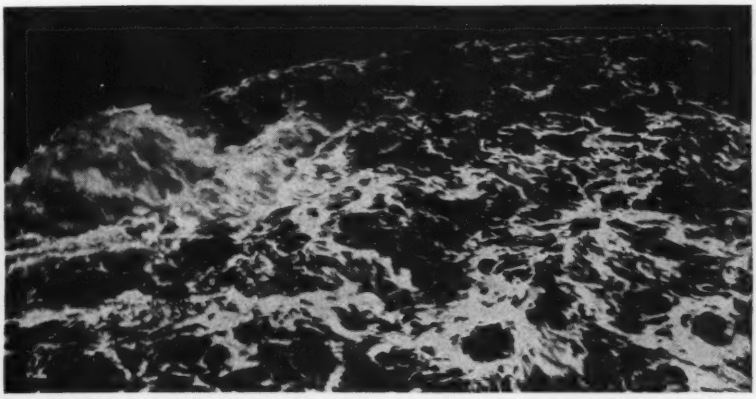


Photo C. Test 1, Kerosene. Surface turbulence directly above point of air injection at bottom of tank.

test as compared with Test 1 may be explained by the fact that the bulge was formed at the center of the surface and cold oil had only to flow 15 ft. in all directions to the shell (instead of 30 ft. flow distance in Test 1). See photos D and E.

Photo D. Test 2, Kerosene. Picture taken during 2½-minute preburn.

From Tests 1 and 2 it was concluded that tank fires in unheated oils with flash points above their storage temperatures can be extinguished by an agitating process that replaces hot surface oil with cooler subsurface oil. It was also evident that agitation can be caused by injection of air into various bottom lines on the tank, the most effective, for a tank of this size, terminating at the center.

Photo E. Test 2, Kerosene. Picture taken at first appearance of agitation at the surface of the kerosene. The fire was out in 5 seconds.

Kerosene Tests in 36 ft. by 21 ft. Tank

These tests were conducted with the same type kerosene distillate as in Tests 1 and 2, but a larger tank, 36 ft. by 21 ft., was used. Depth of kerosene was 17 ft. A water draw-off connection and center

product line was provided for air injection, as in Tests 1 and 2. (For Test 5 an additional shell connection was installed on the opposite side from the water draw-off.)

Photo F. Test 3a, Kerosene. Extinguishment with single powder chemical foam through foam tower. Time of extinguishment 2 minutes, 45 seconds.

Photo G. Test 3b, Kerosene. Extinguishment with air through center line. Time of extinguishment 10 seconds.

Test 3. This test was run to determine comparative rates of extinguishment by foam and by agitation with air injected at the center of the tank. After a 2-minute preburn the fire was extinguished in 2 minutes and 45 seconds with 600 lbs. of single powder chemical foam applied through a foam tower. (Test 3a.) The foam was removed, the oil reignited and allowed to burn for 2 minutes, after which air was injected through the center line at 75 cfm and 6½ psi. The fire was extinguished in 10 seconds (Test 3b.) See photos F and G.

Test 4. Conditions in this test were the same as in Test 3b except that air was injected at the water draw-off. Due to a 30-35 mph wind, difficulty was experienced in extinguishing the fire, more than a minute being required. It was therefore concluded that high wind velocity may retard the spread of cooler oil across the surface in much the same way that wind may retard the flow of foam. See photo H.

Photo H. Test 4, Kerosene. Air injection through water drain-off during 30-35 mph wind. Extinguishment required more than a minute.

Test 5. This test was run to determine the effect of lower rates of air application when injection is through more than one point. Following a 2-minute preburn, air was injected through the water draw-off at low rate to control the fire, and then injected through a second point opposite the draw-off to complete extinguishment. The fire was out in less than a minute. Later tests showed a much shorter time for extin-

guishment and when three-point shell application was tested, extinguishment could be accomplished in less time and with some less rate of air flow.

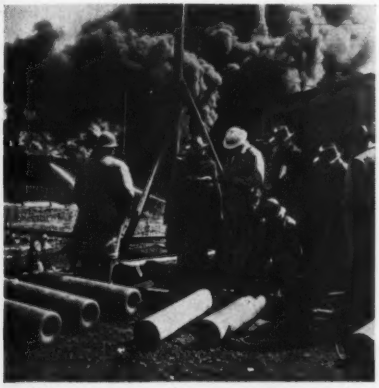


Photo J. Test 6, Kerosene. Picture taken during 2-minute preburn prior to injection of nitrogen.

Test 6. The question arose as to the effectiveness of nitrogen as an agitating agent. In Test 6, following a 2-minute preburn, nitrogen was injected through regular measuring devices to the center of the tank. In two trials on successive days, the shorter time of extinguishment was 30 seconds (the longer was less than a minute), 123 cu. ft. (approximately 16 lbs.) of nitrogen was used, and rate of application was 60 cfm. See Photos J and K.

Photo K. Test 6, Kerosene. Picture taken after agitation by nitrogen had completed extinguishment in 30 seconds.

Test 7. Carbon dioxide was used as the agitating agent in Test 7. The carbon dioxide cylinder had to be laid on its side and piping connecting the cylinder to the injection pipe had to be sufficiently large to prevent freeze-up, but after these precautions were taken, it was possible to effect extinguishment in 12 seconds through center line application of 100 lbs. of CO_2.

Although further tests on tanks of greater than 36 ft. diameter will be required to determine proper rates of application and the effect of other variables, Tests 1-7 leave no doubt that under most conditions, oils with flash points above their storage temperatures can be extinguished by agitation.

Tests on Crude Oil Fires

The second phase of the research program was an investigation of agitation as a means of reducing the intensity and rate of burning of crude oil fires as well as a means of eliminating slop-over. Although it was considered improbable that all crude oil fires could be extinguished solely by agitation, it was felt that if intensity and rate of burning could be reduced and slop-over eliminated, by the agitation process, final extinguishment would be relatively easy with conventional agents.

Crude oils have special characteristics that differentiate their fire behavior from that of refined oils. When a crude oil has burned a sufficient length of time to have established a heat wave, application of water (except when applied sparingly) is dangerous. Water enters the deep heat layer where its conversion to steam with attendant expansion throws burning oil out of the tank. This action is defined as *slop-over* and has been responsible for many

failures to extinguish crude oil fires. On the other hand, *refined oils* are not subject to slop-over since there is no appreciable heat wave established, hence no heat layer build-up. *Boil-over* is another special characteristic of crude oil fires. With crude oils, as with refined oils, a heat wave forms shortly after ignition but whereas the heat layer of refined oils remains shallow, the heat wave of crude oils gradually extends downward and, if the fire is allowed to burn long enough, will reach water that is invariably at the bottom of the tank of crude. When this occurs water is converted to steam and what is commonly known as a boil-over occurs. Agitation as a means of preventing boil-over will be explored at a later date.

Crude Oil Tests in 55-Gallon Drums

Test 8. It was found difficult to reduce the height of crude oil flames in small concontainers by agitation, especially in low flash point crudes, because of the closeness of the heated freeboard to the total surface, but even in small containers slop-over could be readily killed. Using a 55-gallon drum and allowing a 30-minute preburn some reduction in flame was noticed when the crude oil was agitated with a small amount of air, and the slop-over characteristics were definitely eliminated.

Test 9. Many tests were run on drums filled to within 4 to 6 inches of the top with crude and with different depth water bottoms into which air was injected. In one comparative test two drums were used, one with an air line entering below the water bottom. Following a 30-minute preburn, the contents of one drum was agitated with air, after which the fires in both drums were extinguished by slipping a sheet of steel over their tops. Foam was then applied to the drum that had been agitated and nothing happened, but in the case of the other drum, application of foam caused vigorous slop-over (Photos L and M).

Photo L. Test 9, Crude Oil. The burning contents of this drum were agitated and then extinguished by excluding air by means of a sheet of steel over the top of the drum. No slop-over occurred on application of foam.

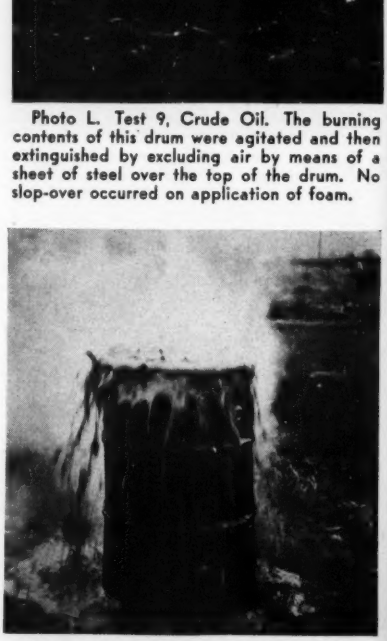


Photo M. Test 9, Crude Oil. Conditions of the test were the same as in Photo L except that the contents were not agitated. Photo shows slop-over when foam was applied.

During the latter test a 30 ft. by 25 ft. tank containing the same type crude oil was allowed to burn without agitation. At the completion of the small scale Test 9 the tank fire was extinguished without

slop-over. Since the drum and tank fires burned for the same time, it was evident that longer burning is required to establish a heat wave sufficient to cause slop-over in a large container than in a small container.

Tests with Pennsylvania Crude

All large scale crude oil tests were run in a 30 ft. by 25 ft. tank into which various agitating devices had been built. Pennsylvania crude oil used in Tests 10 and 11 had the following properties:

API gravity	44.2
Gasoline content	37%
Flash point °F	0
Reid vapor pressure psi	7

Test 10. The 100,000 gallons of crude oil placed in the tank gave a 1 ft. water bottom, 17 ft. of oil and 7 ft. freeboard. Following a 1 minute preburn, air was injected through the water draw-off at 50 to 100 cfm and 6 psi. Flames were checked within 45 seconds but did not recede below the rim of the tank. The fire was allowed to burn for 5 minutes with air agitation and during this time the intensity of the fire was reduced. Had it been desired to put out the flames, fire fighting equipment could have been brought into play to complete extinguishment without the hazard of slop-over, and with a minimum of foam.

Test 11. Air injection through the water draw-off was stopped for 45 seconds at completion of Test 10 to allow the flames to again reach uncontrolled height. Test 11 was then run which consisted of injecting air at 22 to 80 cfm and 7 psi through a pipe network and then through a center pipe. Within 45 seconds flames were brought down within the 7 ft. freeboard with intermittent wind-swept flames above the rim. Flames were held at this height for about three minutes and then brought down to about 15 inches of the surface. With the fire thus under control, two pails of 3 per cent mechanical foam applied through a 1½-in. nozzle from the tank stairway platform completed extinguishment. See Photo N.

Tests with Mid-Continent Crude

These tests (conducted in May 1952) were made on the same 30 ft. by 25 ft. tank as Tests 10 and 11 but different injec-

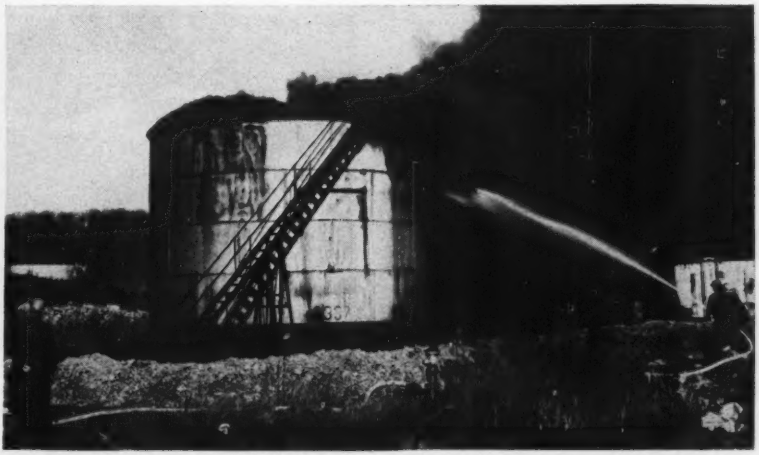


Photo N. Test 11, Crude Oil. This photo was taken during the 45 seconds required to subdue uncontrolled burning by air agitation. Extinguishment was completed with two pails of mechanical foam applied through 1½-in. nozzle from the platform at the top of the stairway.

Photo P. Test 12, Crude Oil. After a 30-minute preburn this fire was extinguished with 20 gallons of 3 per cent mechanical foam. No agitation was employed in this test.

tion devices were used, various agitation media and extinguishing agents were tried and the oil used was Mid-Continent crude having the following properties:

API gravity	37.2
Gasoline content	30%
Flash point °F	0

Test 12. In this first test with Mid-Continent crude no agitation was employed. After a 30-minute preburn the fire was extinguished with 20 gallons of 3 per cent mechanical foam. See Photo P.* (In a later test under similar conditions, but with agitation, only 4 gallons of mechanical foam was required for extinguishment. This test is not reported in detail.)

Test 13. After a 20-minute preburn, air was injected at 70 cfm and 6½ psi through a cross arm in the tank containing a row of 3/16 in. holes. The cross arm was installed so that the holes were on the bottom. Control was established in 30 seconds and maintained for 15 minutes during which observers were able to study the surface of the burning oil from the tank platform. See Photo Q.

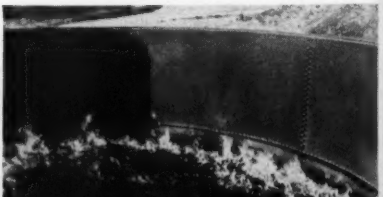


Photo Q. Test 13, Crude Oil. This test differed from Test 12 in that air agitation was employed. Control was established in 30 seconds and maintained for 15 minutes while observers climbed to the top of the tank to get this close view of the controlled burning.

*Although hose streams were used to cool the outside of the freeboard to preserve the tanks for further tests, it may be necessary to use water streams in actual fires controlled by agitation to prevent continued vaporization of adjacent flammable liquids.

Test 14. At the completion of Test 13, the crude was allowed to burn uncontrolled. Air was then injected through a center terminating line and control was again established in a few seconds. In this instance controlled burning was similar to that in Test 13 except that there were less flames at the center of the surface and slightly higher flames at the shell. The results of this test could also be observed at close range. Complete extinguishment was effected with 4 gallons of mechanical foam.

Photo R. Test 15, Crude Oil. This fire was controlled in 1 minute and held for 2 minutes by agitation with 140 cu. ft. of nitrogen.

Test 15. Nitrogen was the agitating agent and dry chemical the extinguishing agent in this test. Nitrogen was injected through the center terminating line after a 15-minute preburn. Control was established in 1 minute and held for 2 minutes with 140 cu. ft. of nitrogen and extinguishment was completed in 15 seconds with dry chemical. The total amount of dry chemical used, including that required to prevent reflash, was 225 lbs. See Photos R and S. (In later tests in which fire was controlled by air injected at 75 cfm about half the contents of a 350 lb. dry chemical unit was used to extinguish.

Test 16. Carbon dioxide injected through the center terminating line following a 5-minute preburn established control in 1½ minutes. The fire was held under control for 1½ minutes by carbon dioxide agitation, then extinguished in 10 seconds with 150 lbs. of dry chemical. (Piping had to be safeguarded against freezing.)

Photo S. Test 15, Crude Oil. After being controlled with nitrogen, flames were extinguished in 15 seconds with dry chemical.

Test 17. This test was similar to Test 14. Following a 10-minute pre-burn, air injected through the center terminating line at 70 cfm and 6¾ psi knocked the fire down in 30 seconds and brought the flames under complete control in 30 additional seconds. It was held under control for 3 minutes, and extinguished with foam.

In addition to these tests, later tests not reported in detail, showed that control similar to that obtained with perforated cross arm or center terminating line application could also be established with application through "hot-taps" on the sides of the tank. It was also determined that elimination of slop-over by agitation reduces the amount of foam required to complete extinguishment from ⅕ to ¼ of that required without agitation. Tests also showed that best results were obtained when foam application was started before agitation was stopped.

Conclusions

Two conclusions can be drawn from tests conducted to date:

1. Fires in oils having flash points *above* their storage temperatures can be completely *extinguished* by agitation.

2. Slop-over characteristics of *typical crude oil* fires can be overcome and *typical crude oil* fires can be *controlled* by agitation.

Author's Suggestions

Based on tests made to date the author makes the following suggestions to those who may wish to use the agitation method.

Kerosene Fires

FOR FIRES IN TANKS OF THE SIZES USED IN THESE TESTS: apply air, nitrogen, carbon dioxide or other agitating agent through existing lines (product, draw-off) at a moderate rate. If the fire is not completely extinguished by moderate rate of application apply the agent at a reduced rate. Then, if this is not successful, gradually increase the rate. If wind velocity interferes, inject air through two or more openings even if it becomes necessary to put "hot-taps" on the tank.

FOR FIRES IN LARGE SIZED KEROSENE AND FUEL OIL TANKS: apply the agitating agent through existing lines to reduce the flames, then tap on lines around the tank at 40 or 50 ft. intervals, injecting air into each as it is tapped on until a sufficient number have been provided to extinguish the fire. If foam is available, agitation even at one point, will increase its effectiveness on a large tank. Even one or two-point applications of agitating agent will reduce a high flash point oil fire to such an extent that a smaller amount of foam will complete extinguishment than would be required with no agitation.

Depth and viscosity add to the effectiveness of agitation. A small surface of high flash point oil is more difficult to extinguish in a nonviscous oil if depth is only a few feet because of the heat in the freeboard and the stack affect. In such cases it may be that concurrent with agitation rapid pumping of cold oil of the same flash point into the tank will permit extinguishment of fire involving very shallow oil. This possibility has not been tested.

Crude Oil Fires

The more viscous the crude (within certain as yet undefined limits) and the greater the depth, the easier can fire be controlled by agitation. Some crude oils with low vapor pressures can be extinguished by agitation alone.

FOR CRUDE OIL FIRES IN TANKS OF THE SIZES USED IN THE TESTS, AND IF THE FIRE HAS BURNED MORE THAN 40 MINUTES: bring the fire under control by applying an agitating agent through existing lines, then start foam application and stop agitation. (Agitation should not be stopped until foam application is started.) If no foam is available apply dry chemical, water spray or other acceptable extinguishing agent.

IF FIRE OCCURS IN A LARGE TANK OF CRUDE OIL: apply the agitating agent through existing lines, then tap on lines around the tank (as recommended for extinguishing fires in large tanks of high flash point oil) until control is established. If, however, foam application can be started within an hour, start agitation with the means available and continue until the foam is applied. If only partial or very little control was accomplished by agitation prior to application of foam, there will be no slop-over if foam application is started above the point of air injection. If water and foam supplies are limited, however, it might be preferable to make "hot taps" on the shell at several points and obtain control by agitation before foam is applied.

Water Works Revenue for Fire Protection

It can be shown that the cost of a plant to supply water to a city or town has two parts: (1) the part which represents the cost of supplying water for general purposes, other than for fire protection, and (2) the part which is the cost of fire protection. The proportions of the total which each of these parts make-up varies from city to city. Failure to recognize both these costs could be serious, particularly in small cities where the proportionate cost of fire protection is the greater.

In some cases where a public utility is inadequately reimbursed for its fire protection costs, the utility has assessed charges against automatic sprinklers and other private fire protection, a practice which is against both the interests of public safety and against the utility's interest since private fire protection lessens the load of general fire protection.

The NFPA Committee on Public Water Supplies for Private Fire Protection in its report on Water Charges* points out that the annual cost of supplying the fire demand of the city as a whole should be paid by the municipality on a reasonable basis. This statement of principle is accepted by most NFPA members and those interested in fire protection, but water utility people would probably say that it is still difficult for them to get adequate revenue to cover fire protection costs.

The whole matter of water and sewage rates has been jointly reported on by committees of the American Society of Civil Engineers, American Bar Association and others in a document, "Fundamental Considerations in Rates and Rate Structures for Water and Sewage Works."† "In water works," this report states, "a contribution should be made by those benefited by the fire protection provided by the works." Also, "in the past, the amount contributed for fire protection has generally been considerably below the cost of providing the service, and with that in mind, a procedure for computing the share of the total annual cost caused by fire protection has been recommended."

This conclusion and its accompanying recommendations are supported by the joint group preparing the report which is presented for information and has not been officially acted on by the ASCE, the Bar Association or any of the other organizations which contributed personnel to the joint study group. The other organizations represented were the American Water Works Association, the National Association of Railroad and Utilities Commissioners, the Municipal Finance Officers Association, the Federation of Sewage Works Associations, the American Public Works Association and the Investment Bankers Association of America.

*_The Relation of Private Protection Equipment to Municipal and Privately Operated Water Works with Special Reference to Water Charges_, Report by NFPA Committee on Public Water Supplies for Fire Protection, 1932 (reprinted with up-to-date charge data in 1941 and 1950), No. 292-M, 12 pages. Printed in National Fire Codes, Vol. IV, Extinguishing and Alarm Equipment, 1951, pages 306-315.

†This report is available as ASCE Bulletin No. 2, from the American Society of Civil Engineers, 33 West 39th St., New York 18, N. Y., for 75 cents.

Sections of the report which will have greatest interest to NFPA members are quoted following:

Chapter 3

Publicly and Privately Owned Utilities

2. SOURCES OF REVENUE

b. *Public Fire Protection*

The treatment of the cost of public fire protection service furnished by water utilities, often misnamed "hydrant rental,"[1] may also differ between publicly and privately-owned utilities. Because the cost of this service is more nearly proportional to the value of the property protected than to the demand for and use of water by utility customers, the charge for public fire protection service is normally charged to the municipality whose citizens receive the protection.

In the case of a privately-owned water utility, the charge for public fire protection service is made to the municipality which in turn includes that amount in its budget to be met largely by property taxes. Sometimes the same procedure is followed if the utility is publicly-owned, but in most instances the charge is reduced materially or even omitted entirely.[2] To make needed funds available in the latter cases, it may be necessary to increase utility revenues by higher rates on other types of service. As an alternative the cost burden of the service furnished by a publicly-owned utility may be included in the general property tax. In the latter case the burden is likely to be borne by the taxpayer in substantially the same proportion as would have been the case if the fire protection charge were paid by the municipality in the form of charges by the utility.

The treatment of fire protection costs and charges requires some modification when one utility sells water at wholesale to another utility for use both for general service and for fire protection. This practice is quite common with publicly-owned utilities. In such cases, that part of the cost of public fire protection represented by additional capacity in source of supply, pumping equipment and feeder mains, is included in the cost of water furnished at wholesale.

Chapter 8

Recommended Procedures for Establishing Fair Rates and Rate Structure

2. WATER RATES AND RATE STRUCTURE

c. *Principles for Allocation of Costs between Public Fire Protection and General Service*

The proper method of determining the costs of public fire protection has long been the subject of controversy. In any analysis of the proper charge, the following basic considerations should be kept in mind.

First, the quantity of water used alone does not represent a fair basis for the allocation of public fire protection costs, since it is relatively small and difficult to measure.

Second, the major portion of the cost of water is created by the necessity of being ready to serve and these costs do not vary with the quantity of water used. Since the public fire protection adds substantially to these so-called "ready-to-serve," "demand" or "capacity" costs, it should pay its proper share of them notwithstanding its small use of water.

Third, the principal ready-to-serve or capacity costs are (1) the return on investment or debt service, (2) depreciation and (3) taxes. The division of these fixed costs requires an allocation of property, since the first two are based upon the value of the works and the largest portion of the taxes of a privately-owned utility are based upon the return on investment.

In determining the cost of public fire protection, there is little difficulty in making a direct assignment of certain items, such as, fire hy-

[1] The term "hydrant rental" probably came into use because the charge for fire protection service often varies approximately in proportion to the number of hydrants in service. Actually the hydrants constitute only a small part of the property necessary to furnish fire protection service.

[2] Ayres, *Basic Considerations in Determining Water Rates*, 42 AM. WATER WORKS ASS'N. JOURN. 981, 986 (1950):

Based on the A.W.W.A. survey of operating data for 1945, it appears that only 193 out of a total of 462 cities, or 42 per cent, collect *any* revenue on account of fire protection. Of the 462 cities reported, 43 are privately owned and 419 publicly owned. Of those privately owned, 81.4 per cent collect a fire charge, but of the publicly owned, only 37.7 per cent.

drants and special fire mains. On the other hand, meters, services, purification works and small distribution mains are assignable mainly to functions other than public fire protection. Allocation of the remaining parts of the property which are used jointly is a more complex problem, however, and is the subject of considerable disagreement. The following general methods of making the allocation have been considered by various authorities dealing with this problem.

(1) General Service as an Incremental Cost

The cost of a system to provide fire protection alone is compared to the cost of a works to provide both functions, and the functions other than public fire protection are assigned only the incremental cost. This method, which assumes that the works were installed mainly for fire protection, seems clearly unrealistic and unfair.

(2) Public Fire Protection as an Incremental Cost

The excess plant method is the converse of Method No. 1 and assumes that public fire protection should be charged with only the incremental cost above the cost of a plant designed to provide the functions other than public fire protection. This theory would grant a special preferential treatment to this type of service although in fact it is a necessary and equally important part of nearly all properly designed water works. Fire protection clearly requires independent consideration in the determination of the size and capacity of the transmission and distribution mains and storage facilities, and the additional cost thereof is not adequately reflected by a charge based solely on the incremental cost of fire protection. The Joint Group has discarded this method because of the discrimination and inequity which it produces.[1]

(3) Capacity Ratio Method

Between the two extremes already discussed is the capacity ratio method, which in one form or other is the method most frequently given weight in current considerations of this problem. This method is based on the theory that neither general use nor fire protection is more important than the other and it, therefore, provides for the allocation of all costs of a joint nature on the basis of some relation between the capacity required for public fire protection and the capacity required for the other uses.

Under one approach to the weighing of relative capacity, commonly referred to as the proportional plant method, the allocation is worked out by estimating the cost of two plants, one to provide public fire protection and one to provide the works required for the other uses. The rate base applicable to the actual existing plant is then allocated between public fire protection and other uses on the basis of the estimated cost of the separate works which would be required for each use. The principal objection to this method is that it involves detailed estimates and studies which are based upon theoretical assumptions. In addition, the ratio thus developed has frequently been applied to all costs without first segregating those directly attributable to each type of use. Such an approach is an exaggeration of the principles behind this method.

A more flexible basis for application of this principle involves a comparison of the maximum demand for fire protection with the maximum demand for general service. As the Joint Group believes that this method provides a fair and practical procedure for making the allocation of the joint costs between fire protection and general service, it is dealt with in some detail.

A number of methods are available for determining the maximum fire demand, but the Joint Group believes that the standards set by the National Board of Fire Underwriters will provide a uniform and generally reliable basis for making this computation. These standards are published by the Board[2] and the publication includes a list of the "required" fire flows for cities of varying populations. For example, the table of required fire flows indicates that for a city with a population of 100,000, the water system should be capable of delivering 9,000 gallons per minute over a period of ten hours. In a city of this size, the maximum demand for fire protection would, therefore, be 9,000 gallons per minute, or 540,000 gallons per hour.

For the maximum general service demand, the group suggests use of the peak hourly demand of the system during the test year. Such data

[1] For a new approach to this method see Ayres, *Basic Considerations in Determining Water Rates*, 42 AM. WATER WORKS ASS'N. JOURN. 981 (1950).

[2] *Standard Schedule for Grading Cities and Towns of the United States with Reference to their Fire Defenses and Physical Conditions* (1952).

should be available from the records of the water works. In addition, it is the only figure which can be fairly compared with the maximum demand for fire protection determined as noted above.

Having determined the maximum demand for public fire protection and that for general service, the allocation of joint costs to fire protection may be calculated by use of a fraction having as its numerator the maximum demand for fire protection and as its denominator the maximum demand for fire protection plus the maximum general service demand.

Although this method generally reaches a satisfactory result in communities where the water works are capable of meeting the Fire Underwriters' requirements, the method should be modified in a community where the works are clearly not up to that standard, since, otherwise, a greater proportion would be assigned to fire service than is justified by the actual capabilities of the plant. In order to allow for this possible deficiency, the Joint Group recommends the following additional adjustment to the proportions determined as indicated above. The Standard Grading Schedule contained in the above-mentioned publication of the National Board of Fire Underwriters assigns to the water supply portion of the municipal fire defense a maximum of 1700 points of deficiency. The publication also sets forth the factors which should be considered in determining the deficiency of any particular water supply. If it is found that a system has 500 deficiency points, relating to the water supply portion of its rating, its percentage of the ideal system could be expressed by the fraction 1200/1700.[8] Applying such a fraction to the percentage determined by relative demands will produce the proper adjusted portion of joint costs assignable to fire protection. This entire computation may be expressed by the following:

$$\frac{\text{Maximum fire demand}}{\text{Maximum fire plus general demand}} + \frac{\text{1700 minus any deficiency points}}{1700} = \text{Portion of joint capacity costs allocable to fire protection}$$

It should be understood that this adjustment is recommended only where the fire system is clearly not up to the Fire Underwriters' standard, and that where only minor deficiencies exist, particularly with regard to such matters as the appointment of employees, the efficiency of the chief executive and the adequacy of records, no adjustment should be made.

Moreover, it is not suggested that this method be used to support or create minor variations in fire protection charges between different local units served by the same water system. However, where the service provided in one local unit is substantially inferior to that in the other local units served by the same water works, then the method recommended above may provide a basis for a differential in fire protection rates.

d. *Classification of Costs for Determining Rate Structure*

In order to determine the joint costs which are to be allocated to fire protection by means of the percentage which has been developed, as well as to prorate the remaining costs of service fairly among the several classes of users within the general service category, it is necessary to make an analysis of all costs. This analysis requires that the costs be broken down into the following classifications:

a. *Capacity Costs*—These costs are those incurred in order to maintain in readiness for operation a plant capable of meeting the total combined demand for all classes of service. They include all operation and maintenance expense which cannot be designated specifically as customer or production costs under b. or c. below, as well as all fixed charges, including depreciation, taxes and return.

b. *Customer Costs*—These costs are those directly related to customers, including such items as reading meters, collection expense, customers' accounting, maintenance of meters and services, as well as other items of a similar nature.

[8] The Joint Group recognized that for many water systems an up-to-date rating by the Fire Underwriters will not be available. However, where this is the case it is possible for the officers and employees of the water system, with the advice and assistance of the District Office of the National Board of Fire Underwriters, to make an analysis of the system and apply the grading schedule in accordance with the instructions contained therein.

c. *Production Costs*—These costs are those which vary substantially or directly with the amount of water distributed, including such items as fuel, power, chemicals, pumping and purification.

Note: It is recognized that administrative and general expenses, such as officers' salaries and office rent, represent a combination of all three classes. It is recommended, therefore, that such expenses be allocated to each class in the same proportion as the total of all other expenses in each class bears to the total of all other expenses in all classes, not including fixed charges.

e. *Allocation of Costs to Public Fire Protection and Suggested Form of Rate*

As previously noted, the cost of public fire protection is essentially of a ready-to-serve or capacity nature and includes very little in the way of customer or production costs. There are, of course, certain costs which are caused solely by fire protection and these costs must be ascertained and segregated. The cost of maintenance of hydrants and the return on the investment in hydrants are the two principal examples of such direct costs. [*Continued on page 99*]

TABLE I

Illustrative Allocation of Fixed Costs

Item		Total Rate Base	Direct To Fire	Direct to General Service	Joint
ALLOCATION OF PROPERTY					
100.1	*Utility Plant in Service*				
301	Organization — Estimated	10,000			10,000
311	*Land and Land Rights*				
311.11	Water Rights	15,000			15,000
311.12	Reservoir Land	250,000			250,000
311.13	Other Source of Supply Land	10,000			10,000
311.2	Power and Pumping Land	25,000			25,000
311.4	Transmission and Distribution	200,000			200,000
311.62	Stores, Shop and Garage Land	50,000			50,000
312	*Structures and Improvements*				
312.11	Collecting and Impounding Reservoirs	1,500,000			1,500,000
312.12	Lake, River & Other Intakes	300,000			300,000
312.2	Power and Pumping Structures	2,250,000			2,250,000
312.3	Purification Buildings	750,000		750,000	
312.62	Stores, Shop & Garage Buildings	250,000			250,000
312.63	Misc. Structures & Improvements	100,000			100,000
316	Electric Pumping Equipment	300,000			300,000
320	Purification System	890,000		890,000	
321	Laboratory Equipment	100,000		100,000	
322	Mains and Accessories	5,500,000		500,000*	5,000,000
323	Services	500,000		500,000	
324	Meters	250,000		250,000	
325	Fire Hydrants	250,000	250,000		
328	Office Furniture & Equipment	150,000			150,000
329	Transportation Equipment	350,000			350,000
331	Shop Equipment	250,000			250,000
332	Tools & Work Equipment	500,000			500,000
334	Miscellaneous Equipment	250,000			250,000
	TOTAL	15,000,000	250,000	2,990,000	11,760,000
	Percentage of Total Property	100%	1.7xx	19.9xx	78.4xx
ALLOCATION OF FIXED CHARGES					
	Return	900,000	15,300	179,100	705,600
	Depreciation	150,000	2,550	29,850	117,600
	Taxes	225,000	3,825	44,775	176,400
TOTAL FIXED COSTS		$1,275,000	$21,675	$ 253,725	$ 999,600

* Mains under 6" not used for fire protection.

xx These percentages have been applied to Depreciation and Taxes as well as Return on the theory that each is related to the percentage of property allocated to each type of service. For greater accuracy taxes could be more closely analyzed since only income and property taxes are closely allied to property and return.

TABLE II — Illustrative Allocation of Total Cost of Service

Operating Expenses	Total Costs	Direct to Fire Service	Joint Capacity Costs	Capacity	Direct to General Service	
					Customer	Production
Source of Supply Expenses						
Labor and Expense	$ 6,900		$ 6,900			
Maintenance	600		300(A)			300
Power and Pumping Expenses						
Labor	117,000					117,000
Power	180,000					180,000
Miscellaneous	5,000					5,000
Maintenance	49,000		24,500(A)			24,500
Purification Expenses						
Labor	43,000					43,000
Chemicals	100,000					100,000
Miscellaneous	1,000					1,000
Maintenance	10,500		5,250(A)			5,250
Transmission and Distribution Expenses						
Labor	35,000		35,000			
Miscellaneous	8,000		8,000			
Maintenance	55,000		27,500(A)	(B)		27,500
Hydrants — Operating and Maintenance	6,000	6,000				
Meters — Operating and Maintenance	17,000				17,000	
Services — Operating and Maintenance	23,000				23,000	
Cust. Accounting and Collecting Expenses						
Salaries and Wages and Expenses	75,000				75,000	
Sales Promotion Expenses						
Expenses and Supplies	8,000				8,000	
Sub-Total	740,000	6,000(0.8%)	107,450(14.5%)		123,000(16.6)	503,550(68.4)
Administrative and General Expenses	130,000	1,040(C)	18,850(C)		21,580(C)	88,530(C)
TOTAL OPERATING EXPENSES	$ 870,000	$ 7,040	$ 126,300		$144,580	$592,080
Fixed Charges (Table I)	1,275,000					
Direct to Fire		21,675				
Direct to General Service				253,725		
Remainder			999,600			
TOTAL FIXED CHARGES	$1,275,000	$21,675	$ 999,600	$253,725	$	$
TOTAL COST OF SERVICE	$2,145,000	$28,715	$1,125,900	$253,725	$144,580	$592,080

(A) For simplicity these Maintenance Expenses have been divided equally between Capacity and Production Costs. Actually the portion of these expenses incurred without regard to output will vary and actual experience in any specific water works may dictate a different division.
(B) For simplicity it has been assumed that there is no maintenance on the small mains not used for fire protection service.
(C) Administrative and General Expenses are allocated in the same proportion as the total of all other expenses in each column bears to the total of all other operating expenses.

TABLE III

Summary of Illustrative Allocation

Fire Protection Service		
Costs allocated directly to Fire		$ 28,715.
Joint Capacity Costs x 20%*		225,180.
Production Cost of Estimated Amount of Water for Fire		5,000.
TOTAL FIRE PROTECTION CHARGE		$258,895.
Remaining Joint Capacity Costs	$900,720.	
Capacity Costs allocated directly to General Service	253,725.	
Total Capacity Costs Allocated to General Service		1,154,445.
Customer Costs		144,580.
Production Costs		587,080.
TOTAL CHARGE GENERAL SERVICE		$1,886,105.

* It is assumed that this plant has a peak hourly demand of 2,160,000 gallons per hour and is located in a city having a population of 100,000. The required fire flow is, therefore, 9,000 gpm, or 540,000 gph and analysis of the plant has shown that it has significant deficiency requiring an adjustment. The percentage is determined as follows:

$$540{,}000 \div \left(540{,}000 + 2{,}160{,}000\right) = \frac{540{,}000}{2{,}700{,}000} = 20\%$$

[*Continued from page 97*]

In addition the capacity costs of a joint nature must be determined and the share of these costs to be collected from public fire protection can then be ascertained by use of the percentage obtained by means of the capacity ratio method discussed above. The determination of what costs are to be classified as capacity costs is always a problem, but the Joint Group believes that the principles embodied in the definition of capacity costs set forth above, as supplemented by the illustrative schedules attached will permit an approximately correct determination of this matter.

Finally there should be added to the revenue to be secured from public fire protection an amount sufficient to cover the production costs of the water which it is estimated will be supplied for fire protection. An illustration of such an analysis is set forth in the attached Tables I, II and III. It should, of course, be recognized that the figures used in these schedules are for illustrative purposes only.

Frequently, the total required revenues from public fire protection are collected solely through a charge per hydrant. This method is subject to serious question since it is totally unrelated to the reasons underlying the charge, and because the high unit cost discourages the installation of hydrants on the existing system. Under ordinary circumstances the hydrant charge should be limited to an amount sufficient to recover only the expenses directly related to hydrants, and that the balance of the public fire protection charges be apportioned on a lineal basis over the distribution mains available for such service. This results in a relatively low hydrant charge, thus encouraging hydrant installation, and a lineal charge having a direct relationship to the service furnished.

The Joint Group recognizes that in some situations this type of charge may have to be modified. For example, in sparsely settled areas it may operate unfairly where new extensions require long lines providing little or no fire protection.

Index to Advertisers

NFPA Quarterly — July, 1952

Acme Fire Alarm Company, Inc. . . . A2
American District Telegraph Company . . . A1
American-LaFrance-Foamite Corporation . . . A3
Ansul Chemical Company, Fire Extinguisher Division . . . A25
"Automatic" Sprinkler Corporation of America . . . A36
Blaw-Knox Sprinkler Division, Blaw-Knox Construction Company . . . A21
Cardox Corporation . . . Inside Front Cover
Central Automatic Sprinkler Company . . . A34
Central Station Signals, Inc. . . . A8
Certain-Teed Products Corporation . . . A5
Chicago Bridge & Iron Company . . . A22
C-O-TWO Fire Equipment Company . . . A31
Fenwal, Incorporated . . . A12
Gamewell Company . . . Inside Back Cover
Globe Automatic Sprinkler Company . . . A26
Grinnell Company, Inc. . . . Back Cover
Gustin-Bacon Mfg. Company . . . A32
Wm. E. Hooper and Sons Company . . . A20
Walter Kidde & Company, Inc. . . . A19
Kinnear Manufacturing Company . . . A15
M & H Valve Fittings Company . . . A30
R. C. Mahon Company . . . A9
Metalbestos Division, William Wallace Company . . . A35
National Fire Protection Association . . . A28
National Foam System, Inc. . . . A13
Nicerol Limited . . . A7
Owens-Corning Fiberglas Corporation . . . A16
Pittsburgh-Des Moines Steel Company . . . A14
Pyrene Manufacturing Company . . . A10
Reliable Automatic Sprinkler Company, Inc. . . . A17
Rockwood Sprinkler Company . . . A29
Safe Manufacturers National Association, Inc. . . . A27
Shand and Jurs Company . . . A23
Star Sprinkler Corporation . . . A33
Tokheim Oil Tank and Pump Company . . . A11
United Steel Fabricators, Inc. . . . A18
Vapor Recovery Systems Company . . . A24
Viking Corporation . . . A6
Von Duprin Division, Vonnegut Hardware Company . . . A4

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Date Desired:.....or.....
(PLEASE LIST ALTERNATE)

Type of Audience:.....
(SCHOOL, LUNCHEON CLUB, TRAINING, ETC.)

Expected Attendance.....

We understand film is absolutely rent-free, postage paid.
We agree to return film the day following our showing.

Organization.....

Authorized by.....

Address.....

City.....State.....

Von Duprin PANIC DEVICES FEATURE SAFE EXIT ®

DISASTER averted by FIRESTOP BESTWALL®

Fire confined to two baths in huge housing project

A vicious fire raged for over an hour in a small area of the Susan B. Clayton Housing Development in Houston, Texas.

But it could not break through the FIRESTOP *Bestwall barrier.*

The unretouched photos tell the story. According to FPHA authorities, FIRESTOP Bestwall "saved the entire building from being a total loss."

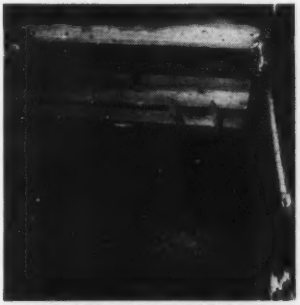
FIRESTOP Bestwall, considered by many as the greatest improvement in gypsum wallboard history, offers up to 1 hour resistance for walls and ceilings.

This amazing gypsum product far outclasses any ordinary wallboard. Besides its superior fire resistance, FIRESTOP has greater structural strength and better sound-deadening characteristics. It is the one and only wallboard carrying the mark of Underwriters Laboratories Ⓡ Re-examination Service.

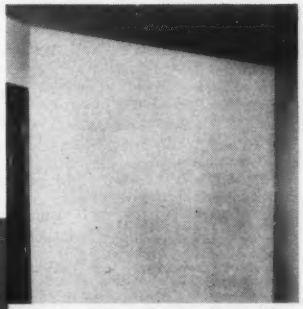
"Facts about FIRESTOP" is yours for the asking. It contains complete information on fire resistance and other characteristics of this remarkable development.

ADD OUR CATALOG to your files

Right foreground shows section where firemen broke through FIRESTOP during blaze. Charred side of wooden stud is the result. Then compare remaining undamaged studs between the FIRESTOP wallboards. Wallboards were broken away after fire to show undamaged condition.



FIRESTOP Bestwall was removed from overhead wooden beams after the fire to show their undamaged condition. Note that walls above tiling remained intact though severely burned.



The FIRESTOP wall adjacent to bathroom remains intact and undamaged. On other adjacent walls the intense heat blackened the nailheads, but FIRESTOP Bestwall remained undamaged.

Certain-teed BUILDING PRODUCTS

Certain-teed

Quality made Certain . . . Satisfaction Guaranteed

CERTAIN-TEED PRODUCTS CORPORATION

ARDMORE, PENNSYLVANIA

In The Background Till Fire Strikes

Fits in smoothly with the most modern interiors. Barely visible, but ready at a second's warning to spring into action. Viking Flush Type Sprinkler Heads offer great *dependability*, plus true functional design. Get all details today from the *Viking* representative in your neighborhood.

THE VIKING FLUSH TYPE SPRINKLER HEAD

VIKING CORPORATION REPRESENTATIVES

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Charlotte, North Carolina

Hudson Viking Sprinkler Co.
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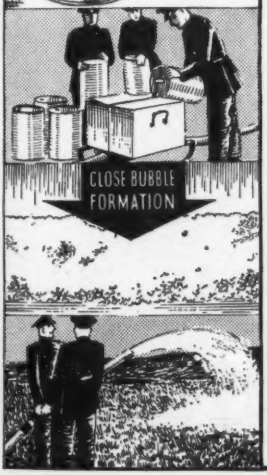
THE VIKING CORPORATION
HASTINGS, MICHIGAN

Kills Oil & Petrol Fires with SPEED & CERTAINTY



★ Nicerol is supplied in heavy gauge steel drums designed for quick release and clean pouring.

★ Nicerol can be used in any type of mechanical foam or air foam apparatus. In this case a base injection type in-line inductor is being operated.

★ The secret of Nicerol effectiveness lies in the small bubble formation. It creates a tough, efficient blanket. 3 gallons of Nicerol and 100 gallons of water will produce over 1,100 Imperial gallons of foam.

★ This gasoline and oil blaze (left) was extinguished in a matter of seconds by a normal mix of Nicerol Foam Compound.

Meet the hazard of fire with Nicerol, the foam compound that kills any oil or gasoline fire quickly and absolutely. Nicerol is a concentrate, producing a heavy type foam of closely-knit small bubbles which form a tough, vapour-tight blanket over the surface of burning oil or gasoline. It is characteristic of Nicerol Foam that it flows with the fire and is highly resistant to flash-back or re-ignition. It can be used successfully in any type of mechanical foam or air-foam apparatus — is equally effective with salt water or fresh and can be stored for years without deterioration.

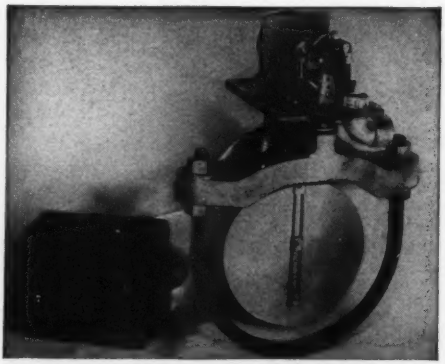
The Royal Navy and the Royal Air Force use it and so do Oil Companies, Fire Equipment Manufacturers, Civil Air Lines, several Commonwealth and Foreign Government departments, and Fire Brigades throughout the world. What better recommendation?

TRADE ENQUIRIES INVITED

For full particulars, samples and catalogues:

NICEROL LIMITED, LISBURN, N. IRELAND

Telephone: Lisburn 2027. *Telegrams: Nicerol, Lisburn.*



5-inch size shown above. To install simply drill hole in pipe.

CENTRAL STATION SIGNALS, INC. Model PRS

Waterflow Alarm Device is approved by both the Factory Mutual Laboratories and Underwriters' Laboratories, Inc. In hundreds of installations it has proved to be the ideal alarm device for sprinkler systems.

SAVE VITAL MATERIALS! Install this water flow alarm device in place of bulky alarm valves. Only 10 oz. of vital material used in our water flow switch.

- **Made in all sizes from 2½" to 8"**
- **It is positive in operation**
- **Has instantly recycling pneumatic retarding device which prevents false alarms**
- **Has enclosed electrical contacts for 15 amp, 125 volts AC and ½ amp, 125 volts DC**

By installing this most economical alarm device, you will know instantly where the water is flowing. Many plants are having them installed on each floor or in each section. They save water damage.

This device can also be obtained as Model PRT, a coded waterflow transmitter from which signals are received on a punch register and single stroke gong. Practically any number can be installed on a two-wire system, thus resulting in considerable savings on wiring.

WE SOLICIT YOUR INQUIRIES

CENTRAL STATION SIGNALS, INC.

Manufacturers of all kinds of approved devices used in Central Station Systems or Class 'A' or Class 'B' Proprietary Fire Alarm Sytems, either automatic or manual.

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Automatic Rolling Steel
FIRE DOORS *and* WINDOW SHUTTERS PREVENT SPREAD *of* FIRE!

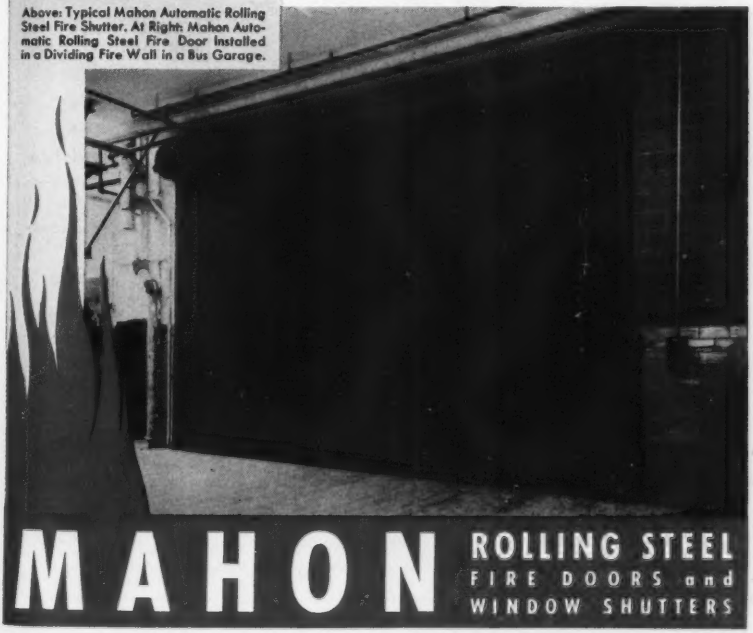
You need good automatic fire doors in fire walls, corridors, and vertical shafts . . . in some cases automatic rolling steel window shutters are necessary to protect your building and its contents from fires which may originate in nearby buildings. Many, many cases are on file which confirm that timely action of automatic rolling steel fire doors and window shutters have confined a fire to its point of origin and permitted its being extinguished with comparatively small damage. Make a survey of your building now, and don't delay action. You will find a Mahon Automatic Rolling Steel Fire Door or Window Shutter to meet each of your requirements—all bear the Underwriters' Label. These automatic fire doors may be operated manually or mechanically in every day use. If a fire should break out while they are in the open position, the automatic mechanism will close the door, cutting off drafts and preventing the spread of the fire. See Sweet's Files for complete information, or ask for Catalog G-52.

THE R. C. MAHON COMPANY

Detroit 34, Michigan • Chicago 4, Illinois

Manufacturers of Automatic Rolling Steel Fire Doors and Window Shutters. Also Many Types of Standard General Service Rolling Steel Doors and Grilles, Insulated Metal Walls, and Steel Deck for Roofs, Floors and Partitions.

Above: Typical Mahon Automatic Rolling Steel Fire Shutter. At Right: Mahon Automatic Rolling Steel Fire Door Installed in a Dividing Fire Wall in a Bus Garage.



MAHON ROLLING STEEL FIRE DOORS and WINDOW SHUTTERS

For industrial applications involving flammable fluids your surest protection is

Pyrene REG. U.S. PAT. OFF.

AIR FOAM

Air foam is the most effective, most economical agent available for extinguishing flammable liquid fires . . . and the easiest to apply. Pyrene* makes the most complete line of equipment for its application. Whatever the size or nature of your hazard, Pyrene can handle your needs. Pyrene Air Foam Equipment is flexible. Installation can be fixed or portable. And Pyrene Foam Compound is sparing of water—one gallon added to 20 gallons of water produces about 200 gallons of foam. Complete data available. Send for it today!

PYRENE FOAM PLAYPIPES

Portable; easy for one man to carry and use. Quickly couples into standpipe hose. Makes foam wherever water pressure is 50 pounds or more. Four sizes, capacities 200 to 1,600 gallons of foam per minute.

PYRENE SPRAY SYSTEMS

Large and small, manual and automatic. Proportioners mix foam and water in line leading from water source to foam-making spray nozzle. Gives complete protection to such hazards as machinery spaces, mixing tanks, loading platforms, etc.

PYRENE STORAGE TANK SYSTEMS

Fixed systems specially designed to meet the fire protection requirements of your storage tanks. Simple, manual, one-man operation. Special connections provided for hooking in playpipes for smaller fires—spill fires, for example.

*T.M. Reg. U.S. Pat. Off.

PYRENE MANUFACTURING COMPANY
582 Belmont Avenue Newark 8, New Jersey
Affiliated with C-O-Two Fire Equipment Co.

Pyrene AIR FOAM

SAFER

liquid handling for Industry

THIS NEW TOKHEIM HAND PUMP contributes to safer handling of volatile liquids wherever used. Stops wasteful dripping and slippery floors. Reduces fire hazard and accidents common to other methods of liquid transfer. Approved for handling petroleum liquids—ideal for many others. Available in hose and spout models—for drums, skid tanks and underground installations. Order from your dealer, your oil company or your Tokheim representative. **Write factory for literature.**

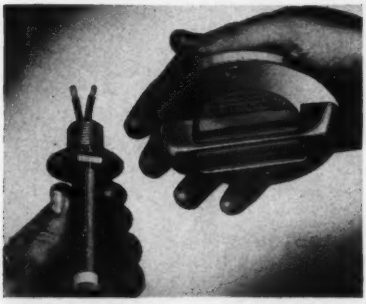
General Products Division

TOKHEIM OIL TANK AND PUMP COMPANY

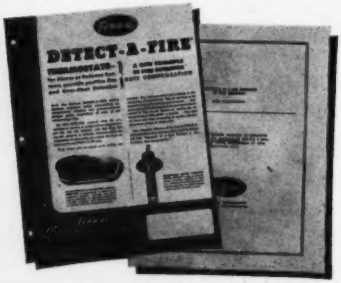
1686 Wabash Avenue, Fort Wayne 1, Indiana

Factory Branch: 1309 Howard Street, San Francisco 3, California

PREVENT FIRES LIKE THIS. A $200,000 loss, as in this paint and varnish factory, can happen only where *full* fire protection is lacking. To more and more men responsible for protecting life and property, *full* fire protection means a carefully engineered alarm or release system incorporating Fenwal DETECT-A-FIRE® thermostats.



YOU REDUCE EXPENSES as well as risks when you specify DETECT-A-FIRE thermostats in your fire detection equipment. Long service life, corrosion resistance and repeatability assure long-term economy. Fenwal DETECT-A-FIRE thermostats are listed by (UL) . . . approved by (FM)



THESE FREE BULLETINS contain complete details on Fenwal DETECT-A-FIRE thermostats — the only units bringing you the benefits of Rate-Compensation Actuation, a new principle of fire detection. Fenwal engineers will gladly work with system installers to incorporate the benefits of *full* fire protection and *long-term* economy.

Write Fenwal, Incorporated, 147 Pleasant Street, Ashland, Mass.

Fenwal

DETECT-A-FIRE®

Thermostats

Dynamic, Rate-Compensation Actuated Fire Detectors

ENGINEERED Foam Fire Protection

increased use of gasoline, alcohols, acetone, or other flammable liquids creates serious hazards you may have overlooked in your plant. Check your present protection facilities now so you can meet modern emergencies with fully positive, fire-killing foam.

National Foam engineers can survey your plant, study risks involved, and then determine the type of *foam protection* best suited to your plant's requirements . . . mechanical or chemical foams . . . the most complete choice of devices available . . . Foam Chamber for Cone Roof Tanks, Overhead Spray Deflectors, Nozzles, Dip Tank or Drainboard Systems, or even small extinguishers and other devices . . . whichever is best suited to your particular needs. Large plant, or small, National Foam specialists are ready to *engineer* foam protection to meet the hazards of your plant.

Let National Foam engineers and chemists show you how to get the best *foam* fire protection today! Consult your nearest National Foam Distributor, or write us direct about your problem.

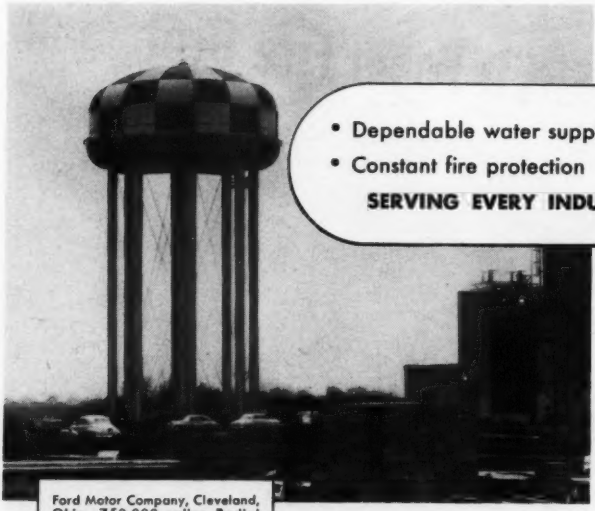
NATIONAL

FOAM SYSTEM, INC.

Headquarters for Foam Fire Protection

WEST CHESTER, PENNA.

NATIONAL FOAM CONTINUOUS FOAM PRODUCTION SYSTEM



- Dependable water supply
- Constant fire protection

SERVING EVERY INDUSTRIAL NEED

Ford Motor Company, Cleveland, Ohio. 750,000-gallon Radial Cone Bottom Tank. Diameter 73'; head range 25'; height to bottom 100'.

Ford Motor Company, Hamburg, New York. 250,000-gallon Double Ellipsoidal Tank. Diameter 38'; head range 33'; height to bottom 123'.

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Elevated Steel Tanks

These recently-erected tanks, serving the water storage requirements of two new Ford Motor Company plants, typify the hundreds of industrial PDM Elevated Steel Tank installations for companies of every size from coast to coast. Let us consult with you on the type and capacity of tank best meeting the demands of economy, efficiency and safety for your plant.

PITTSBURGH • DES MOINES STEEL CO.

Plants at PITTSBURGH, DES MOINES and SANTA CLARA

Sales Offices at:

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CHICAGO (3) 1272 First National Bank Bldg.
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SEATTLE . . . . . 576 Lane Street
SANTA CLARA, CAL. . . 675 Alviso Road

Fire can START anywhere . . .

"AKBAR"

the famous KINNEAR Rolling Fire Door

AKBAR Fire Doors have been *proved* in major conflagrations throughout the country. When fire threatens, their quick, positive, automatic action stops dangerous flame-spreading drafts by blocking openings with a curtain of steel.

In emergency release, the doors are pushed down by a strong spring, to assure positive action. For the safety of building occupants, downward speed of the doors is regulated. And the doors can be opened after closure, for emergency exit. Another device stops the door at floor level, with the steel curtain covering the entire opening — it will not sag, or drop through a fire-weakened sill.

When not in use, Akbar doors remain coiled overhead, out of the way. Approved by Underwriters' Laboratories, Inc., they can be installed in openings of any size, in old or new buildings. They can be equipped for regular, daily service, with motor operation. However, non-labeled Kinnear Rolling Doors are recommended where maximum fire protection is not required. Write for catalog.

KINNEAR ROLLING DOORS

Counterbalanced for Quick Action

The KINNEAR MFG. CO.
2250-70 Fields Avenue, Columbus 16, Ohio
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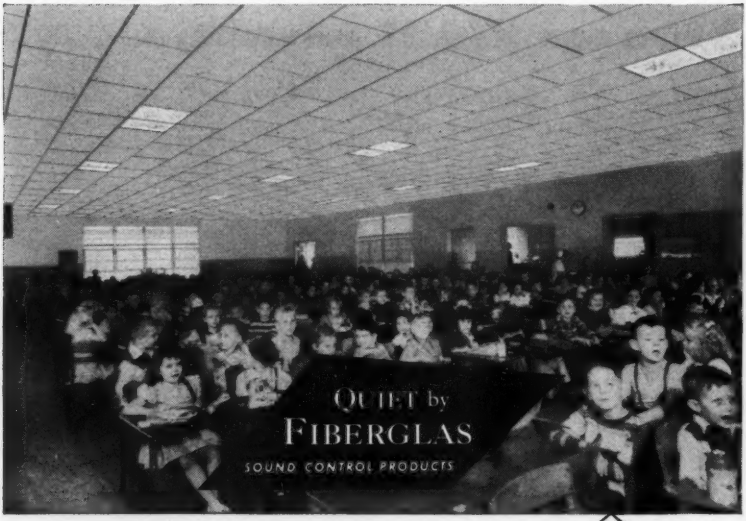

Safety WHERE PEOPLE GATHER ...WITH *NON-COMBUSTIBLE* FIBERGLAS* ACOUSTICAL PRODUCTS

By accepted standards of measurement, Fiberglas Sound Control products are rated *non-combustible*... an absolute necessity in more and more buildings of all kinds. In fact, fire safety, high noise reduction and low cost are three inseparable advantages to be obtained with every Fiberglas Sound Control product. High light reflection, lightweight, dimensional stability and easy maintenance are other important qualities.

For complete information, call your Fiberglas Acoustical Contractor, listed in the yellow pages, or write to: OWENS-CORNING FIBERGLAS CORPORATION, Dept. 117-G, Toledo 1, Ohio.

HIGH NOISE REDUCTION

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FIRE SAFETY

OWENS-CORNING FIBERGLAS

SOUND CONTROL PRODUCTS

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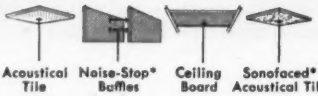

RELIABLE

AUTOMATIC SPRINKLER DEVICES

PROTECTING LIFE AND PROPERTY FOR OVER 25 YEARS

Reliable Automatic Sprinkler Devices have an excellent field record . . . superb in design and construction . . . are universally approved by all Fire Insurance and Governmental Authorities . . . and effect maximum reductions in fire insurance premiums.

They comprise a complete line including Automatic and Open Sprinklers, Alarm Valves, Dry Pipe Valves, Accelerators, Circuit Closers, Water Motors and all other accessories required in Sprinkler Systems.

PROMPT SERVICE BY LOCAL RELIABLE REPRESENTATIVES

Experienced Reliable Representatives are located throughout the United States, in Canada and foreign countries. These local organizations can install a Reliable Automatic Sprinkler System designed for each particular requirement. Write us for the name of the Reliable Representative nearest you.

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Manufactured and Distributed by

The Reliable Automatic Sprinkler Co. Inc.

BRONX STREET MOUNT VERNON, N. Y.

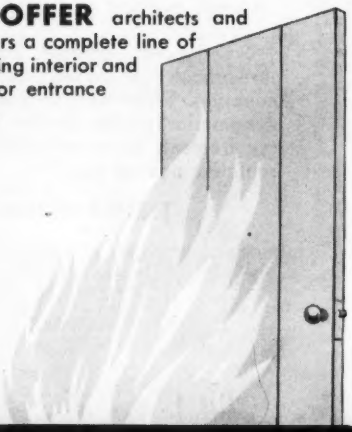
USF

MADE STEEL DOOR HISTORY!

FIRST **TO DESIGN** a 1⅜" Hollow Steel Door that meets the ASTM-1½ hour FIRETEST requirements and receive approval of the New York Board of Standards and Appeals.

FIRST **TO RECEIVE** approval by the Underwriters' Laboratories, Inc. of a 1⅜" Hollow Steel Door for "B" Label requirements.

FIRST **TO OFFER** architects and builders a complete line of matching interior and corridor entrance doors.



It's the USF *"Wooster Door"*

USF USS STEEL

UNITED STEEL FABRICATORS, INC.
WOOSTER, OHIO

MANUFACTURERS OF

Hollow Metal Doors and Frames • Prefabricated Metal Buildings
Corrugated Metal Window Wells • Highway Guard Rail
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RECHARGES at any air pump!

For fires in textiles, flammable liquids and electrical equipment, you can't beat the New Kidde 5 pound Dry Chemical Extinguisher. It has more fire-killing action than any other unit of its size. It operates by air pressure and can be recharged at any air pump.

FOR OUR LOCAL DEALERS
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Walter Kidde & Company, Inc.
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BLOCK THAT FIRE HAZARD WITH

The revolutionary Hooperwood FIRE-CHIEF® process really makes canvas highly flame-resistant. FIRE-CHIEF also makes the canvas resistant to the ravages of water, weather, and mildew. Tensile strength is preserved, and the canvas stays pliable. It lasts *several times* as long as untreated canvas.

FIRE-CHIEF is available in three forms: As finished Hooperwood FIRE-CHIEF Canvas; as protection we apply to the customer's own fabrics; as FIRE-CHIEF Compound to be applied to new or used canvas. Write us today for further information on Hooperwood FIRE-CHIEF Canvas and FIRE-CHIEF processing.

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General Sales Offices: **Juniper and Cherry Sts., Philadelphia 7, Pa.**
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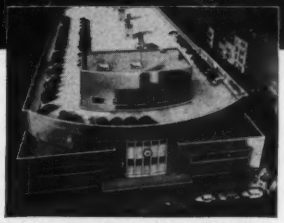
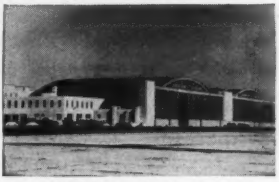
Hooperwood Mills: **Woodberry, Baltimore 11, Md.**

Pennsylvania-Duquesne Warehouse, Pittsburgh, Pa. Built by P.R.R. and operated by Pitt-Penn Terminal Co.... the last word in streamlined efficiency and safety. Protected throughout by a Blaw-Knox Dry Pipe Sprinkler System supplying 5,025 Underwriter-approved sprinkler heads.



Midtown Bus Terminal, New York City
9,763 Underwriter-approved sprinkler heads.



American Airlines, Chicago Airport...
Blaw-Knox fire protection throughout.

N. Y. Pier No. 42... Norwegian-American Lines protected with 6,726 approved sprinkler heads.

The utmost in protection for your property and goods in transit

While having no insurable interest in consigned merchandise, many transportation companies protect both warehouses and contents with Blaw-Knox Automatic Sprinklers. Insurance companies agree that no other fire protection equals an on-the-spot, fast-acting sprinkler system *engineered* for the hazards involved. Glad to give you a preliminary survey and estimate cost without obligation.

BLAW-KNOX SPRINKLER DIVISION
OF BLAW-KNOX CONSTRUCTION COMPANY
829 Beaver Ave., N.S., Pittsburgh 33, Pa.

BLAW-KNOX
AUTOMATIC
FIRE PROTECTION SYSTEMS

ELEVATED STEEL TANK

lowers Insurance Rates

This 100,000-gal. elevated steel tank provides gravity water pressure for fire protection at the Mall Tool Company's plant near Crete, Ill.

The plant, consisting of 11 buildings, has an area of 110,000 sq. ft. Seventy-five thousand sq. ft. of floor area is protected by an automatic sprinkler system containing 753 sprinkler heads. The elevated tank, which is 100-ft. to the bottom, provides the primary water supply for the sprinkler system and fire hydrants located throughout the grounds. The secondary supply is a deep well.

According to the Mall Tool Company, "Insurance rates at this location without adequate fire protection such as an adequate water supply and sprinkler system would be prohibitive."

The Chicago plant of the Mall Tool Company is also protected from fire by a 60,000-gal. Horton elevated steel tank, 70-ft. to the bottom, which was installed in 1949.

CHICAGO BRIDGE & IRON COMPANY

CLEVELAND	CHICAGO	BIRMINGHAM	LOS ANGELES
HAVANA	DETROIT	ATLANTA	WASHINGTON
HOUSTON	TULSA	NEW YORK	PHILADELPHIA
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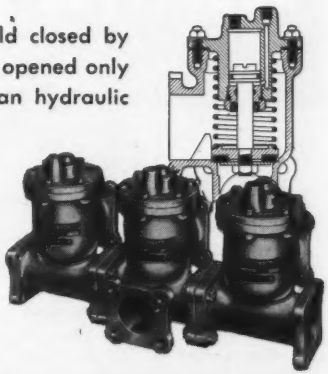
Plants at Chicago, Birmingham, Salt Lake City and Greenville, Pa.

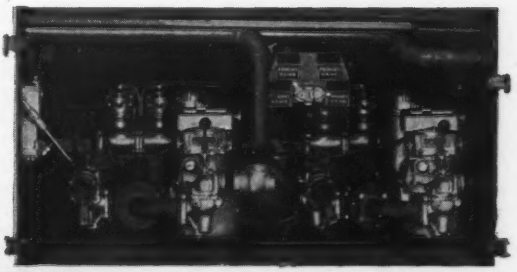
MORE DELIVERIES PER DAY!

Though the Shand & Jurs Hydrafold discharge systems for petroleum truck tanks do not encroach on Mr. Stork's field of endeavor, they do provide a SAFE means of delivering many more gallons of product per day. This system, S&J Hydrafolds in conjunction with S&J Internal Safety Valves, has earned an enviable reputation for quick, trouble free manipulation, full flow and fast delivery —all with greater SAFETY.

The Hydrafolds and Internal Valves, held closed by constant internal spring pressure, can be opened only by the S&J Operator which is actually an hydraulic pump. In case of fire, small fusible plugs inserted in tees in the lines melt at 165°, releasing hydraulic pressure and allowing any open valve to close instantly. For faster deliveries with greater SAFETY insist on S&J Hydrafold discharge systems.



S&J



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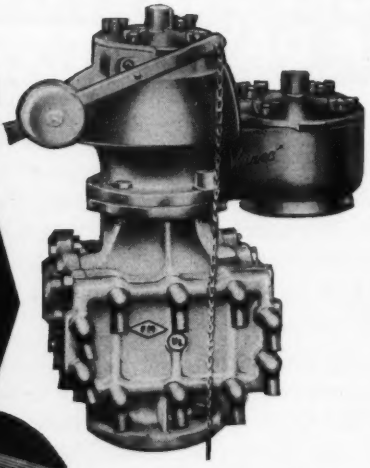
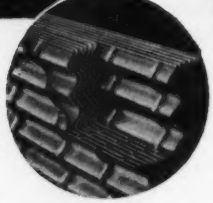
EXTRA **Safe**

with "Varec" FLAME ARRESTERS In combination with your VENT VALVES





"VAREC" Fig. No. 5800 Vent Unit consisting of "VAREC" Conservation Vent Valve in combination with "VAREC" Flame Arrester.

The belief that conservation vents or breather valves alone will prevent travel of flame back into flammable liquid storage tanks is questionable because of the many contributing factors. Careful authoritative analysis reveals that valves by themselves do provide *some protection* but this "protection" *is by no means adequate* under all circumstances.

Safety authorities emphatically advise that "vent valves are not regarded as providing the required protection against fire and explosion." A textbook on safety states that "a conservative policy is to provide flame arresters in conjunction with other vent equipment on all cone-roof atmospheric tanks handling oils with a flash point up to 200°F open cup."

"VAREC" Flame Arresters when used as a unit with "VAREC" Vent Valves give you full fire protection at extremely low cost. Average installations run approximately .1 of 1% of your investment in tank and products. Consult your nearest "VAREC" representative or write for further information.

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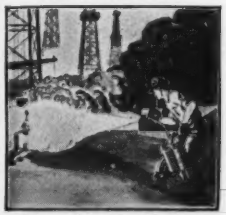
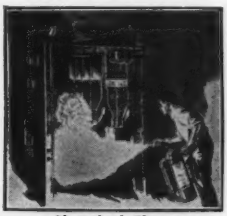


Flammable Liquid Fires

Gas Fires



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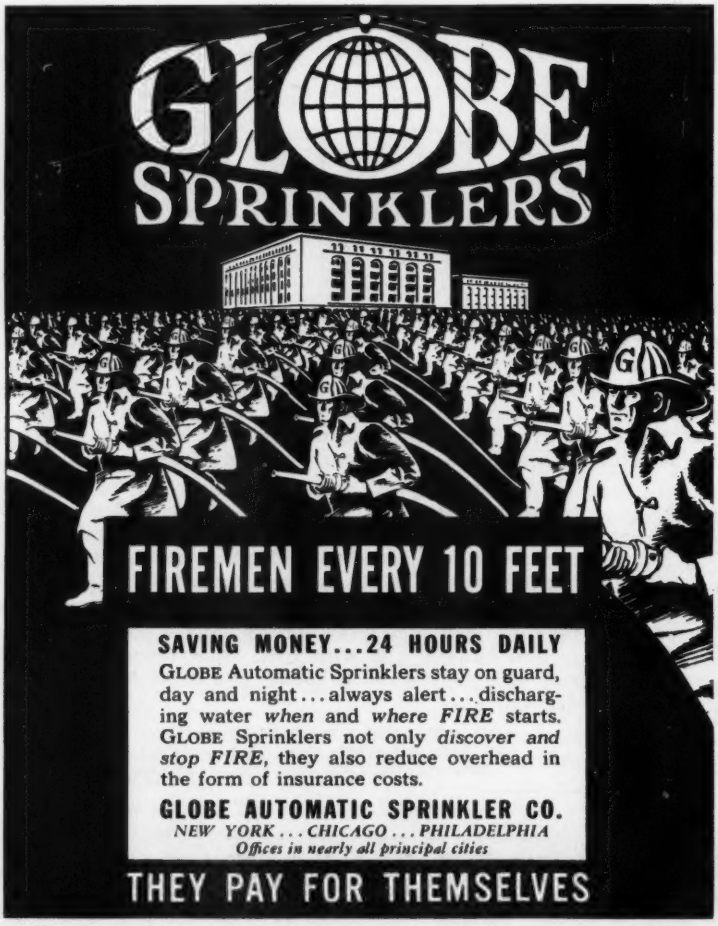
PROTECTION
AT ITS BEST



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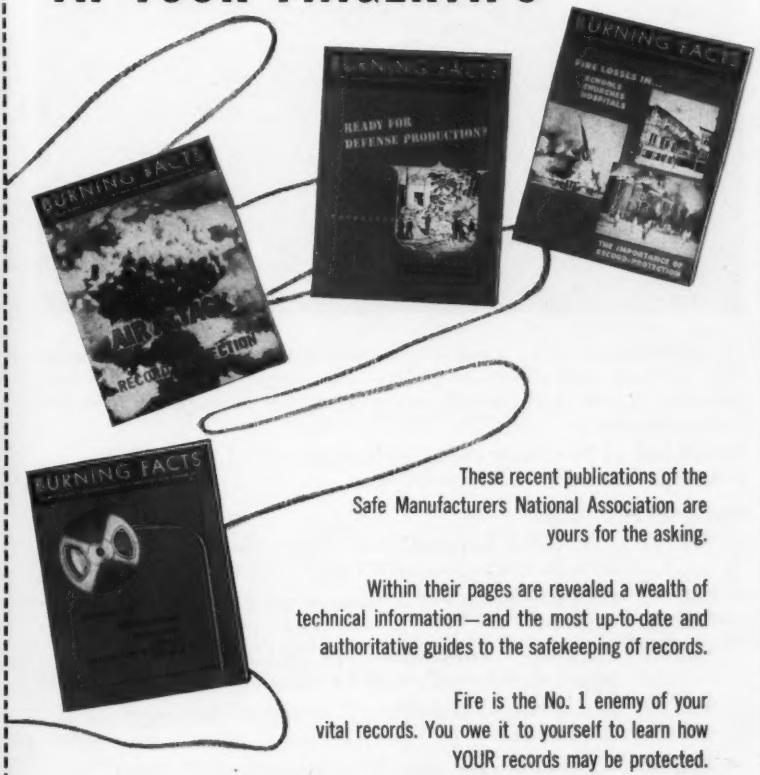

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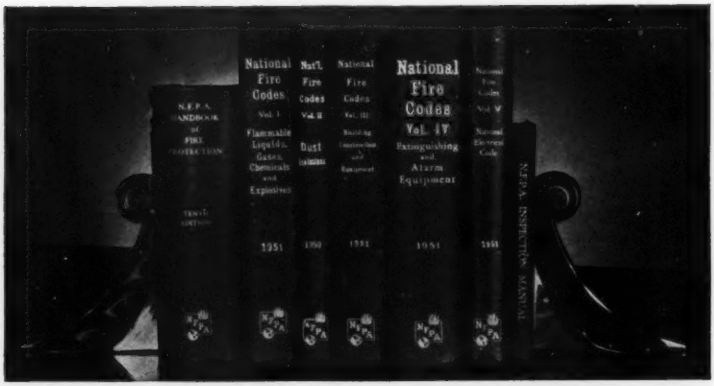

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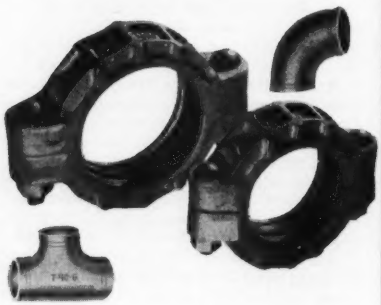

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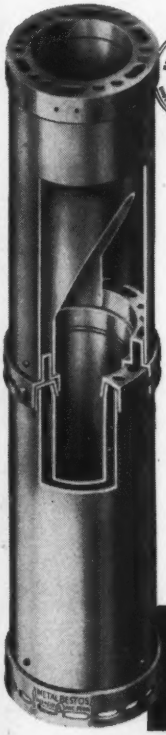

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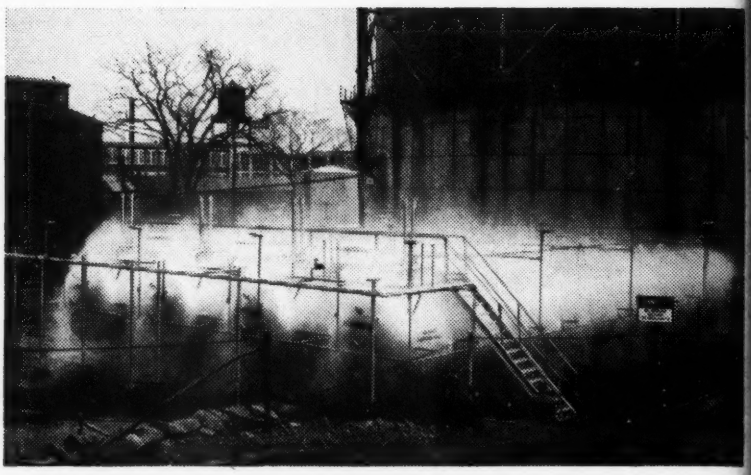

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